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RADIOLOGICAL HEALTH DATA AND REPORTS

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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Studies of Chemical and Radiochemical Composition of Natural Gas from the Cavity Produced by the Project Gasbuggy Nuclear Shot[1]

Charles F. Smith and *Floyd F. Momyer*[2]

Data relating to the chemical and radiochemical results from Project Gasbuggy chimney-gas samples obtained prior to 210 days after detonation (December 10, 1967) are presented for significant non-radioactive components of the gas and for tritium and krypton-85. A discussion of changes in composition occurring during the flaring of 5×10^7 ft^3 gas in the late spring of 1968 is included. Some interpretation of the observed changes is advanced but with the data now available, no definitive conclusions seem warranted. This is a status report of the continuing effort to define and understand the chemical and radiochemical aspects of project Gasbuggy.

Major constituents of the Gasbuggy gas during the period from 34 days to 200 days following the detonation were methane (increasing from 37 to 44 percent), ethane (increasing from 4 to 5 percent), propane (constant at ~1 percent), carbon dioxide (constant at ~36 percent), hydrogen (decreasing from 17 to 12 percent) and carbon monoxide (decreasing from 4 to less than 2 percent). Much more significant changes were observed during the first month. The major reactions used to explain these trends are:

$$CO + H_2O \rightarrow CO_2 + H_2 \quad \text{and} \quad 4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$$

Krypton-85 concentration (2.8 μCi/ft^3) NTP (normal temperature and pressure) remained essentially constant over the entire sampling period implying mixing with a constant volume (1.2×10^8 ft^3 NTP) of noncondensable gas during this time.

Tritium was observed primarily as hydrogen gas soon after detonations. A rapid decrease in HT came within the first month converting most of the HT to HTO but producing some CH_3T and C_2H_5T. The predominant tritium-containing species, except at very early time, is CH_3T, at a concentration of 12 to 14 μCi/ft^3 NTP. Both CH_3T and C_2H_5T concentrations increase slightly over the first 200 days, that of HT continues to decrease. The ratios $\frac{CH_3T}{CH_4}$ and $\frac{C_2H_5T}{C_2H_6}$ are essentially constant over the period from 30 to 200 days implying that the exchange equilibrium was attained rapidly. The ratio HT/H_2 continues to decrease over the same period implying a continuing influx of non-tritiated water into the chimney and a reasonably rapid exchange reaction between HT and H_2O.

Changes in concentrations of cavity gas components as a function of flow rate indicate that removal of 30 percent of the original chimney gas was accomplished by flaring 5×10^7 ft^3 at a rate of 5×10^6 ft^3/day. This result is encouraging but the test was too short to provide verification of this process as a reasonable method of reducing contamination levels.

Among the more important problems related to the application of nuclear explosives to stimulation of natural gas fields is that of radioactive contamination of the gas in the chimney formed by the detonation. One of the primary objectives of Project Gasbuggy is to determine the gas quality with regard to contamination by radioactivity and to evaluate various techniques suggested for reducing this contamination.

A large quantity of data has been collected from analysis of the Gasbuggy chimney gas, and some systematic trends have been observed. Although some of the chemical and radiochemical analyses are not yet complete, that portion relating to the most important nuclides, tritium and krypton–85, can be presented, along with the mass spectrometric analyses for the major components of the gas.

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[1] Work performed under the auspices of the U.S. Atomic Energy Commission. This paper was presented at the Society of Petroleum Engineers Meeting in Houston, Tex. on September 30, 1968.

[2] Dr. Smith and Dr. Momyer are associated with the Lawrence Radiation Laboratory, University of California, Livermore, Calif.

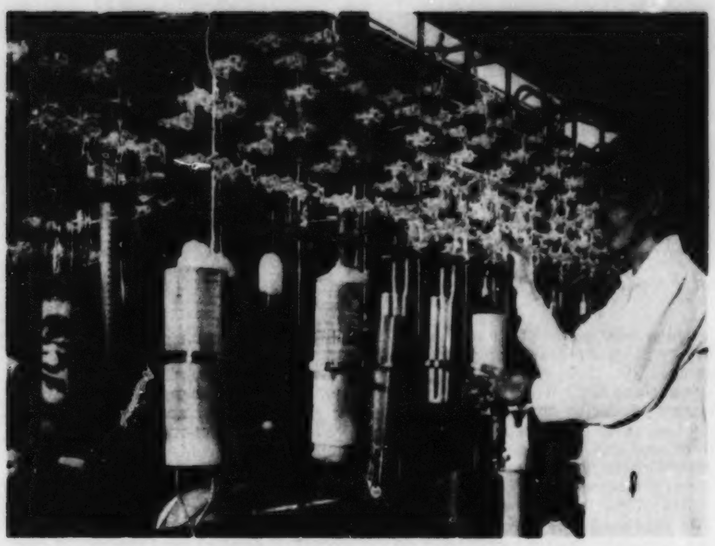

Figure 1. Chromatographic gas columns in the Radiochemistry Laboratory at the Lawrence Radiation Laboratory

Only a tentative assessment of the incomplete results is intended by this presentation. More information must be assembled before detailed interpretations of the chemistry can be made. Indeed, the lack of samples at early times when major changes were occurring may cause ambiguous interpretation of the processes involved as far as this particular experiment is concerned.

Analytical procedures

It might be of some interest to describe briefly the process by which the data are obtained. The sample is introduced to the separation system and condensed on a large activated charcoal column (figure 1). These separation systems are, in reality, large-scale gas chromatographs. Samples of Gasbuggy gas as large as ½ ft^3 can be easily separated, however, the typical sample size is 1 liter.

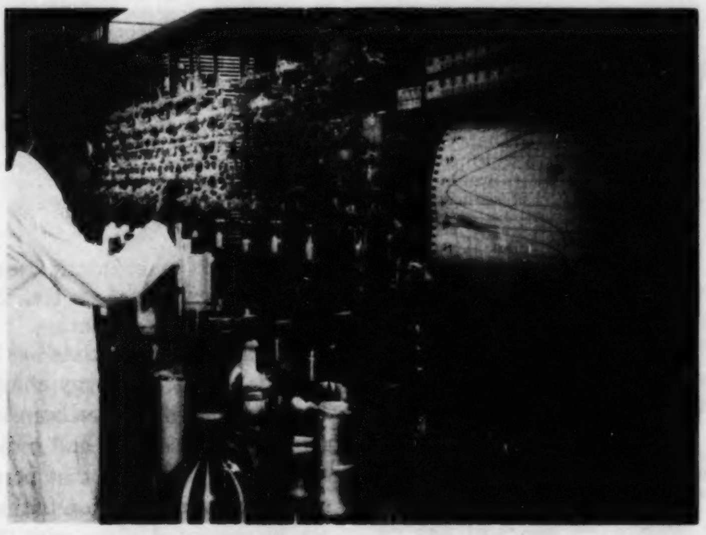

Figure 2. Chart recorder and ionization counter apparatus at Lawrence Radiation Laboratory

Helium is passed through the column as the temperature is progressively raised stepwise. The gases pass through the column in inverse order of their degree of adsorption. For a complete separation, both charcoal and a molecular sieve are employed at temperatures ranging from liquid nitrogen (−240°F) to +600°F.

During the course of an elution, the procedure is monitored using a thermal conductivity detector and an ionization chamber. These are read out on the chart recorder (figure 2). The purified gas is recovered for transfer to a radiation counter.

Two types of counters are used. The "gas-cell," thin-window proportional counter is employed for krypton-85 radioassay. The krypton is contained in small cells that are loaded on a sample changer (figure 3). Each cell, in turn, is rotated underneath the lead shield of the counter, where it is raised to the counting position. Gases containing tritium are placed in internal proportional counting tubes and become a part of the fill gas in the active volume of the tube (figure 4). These tubes are counted inside a shielded cave.

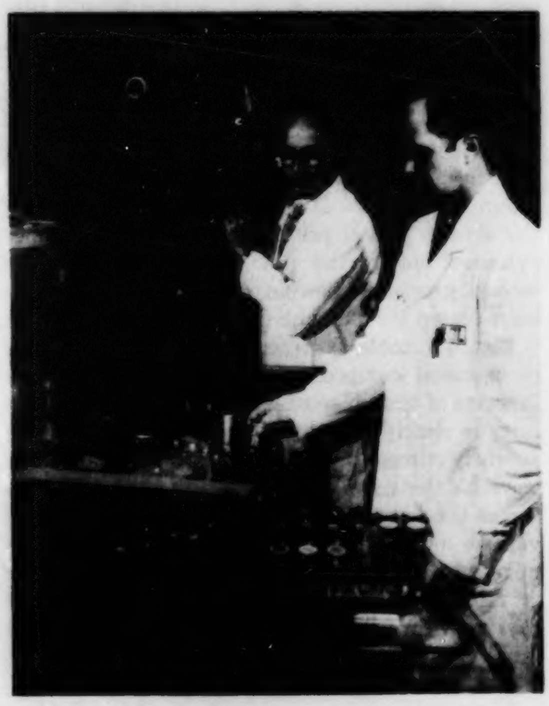

Figure 3. Gas cells containing radioactive krypton-85 separated from Gasbuggy chimney gas samples, being loaded on an automatic sample changer

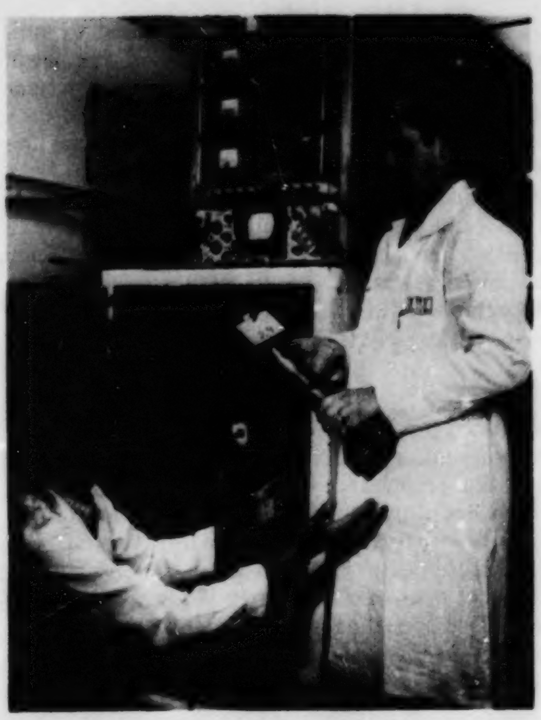

Figure 4. Internal proportional counter containing tritium contaminated gas separated from Gasbuggy chimney gas samples, being placed in a shielded arrangement

Systematic errors which may be present in these determinations are not estimated. The calibration factors for the two counting methods are known to within a few percent and were determined by counting gases of known radioactivity. A conservative estimate of the uncertainty in the absolute value of these measurements is, therefore, less than ±10 percent of the value given. Precision of these determinations is improved by our standard practice of counting replicates. Results of duplicate counts are averaged to obtain the final result and an estimate of its reliability. The numbers to be presented here have individual standard deviations of less than 3 percent. Precision within a group of samples includes this uncertainty but is primarily determined by real variations in sample composition between samples. As will be seen, this variation is significant for hydrogen but much less so for the other gases of interest. In the data which follow, the precision of the measurements is indicated by inclusion of ±1 sigma (standard deviation of the mean) as the indicated uncertainty.

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In the plotted data, error bars are used to indicate precision, standard deviation of the mean included. Where no such bars are shown, the error bars lie within the plotted point system. All data are related to cavity gas after air (based on O_2) was removed from the sample.

Analytical errors vary according to the percent composition, but are generally less than 1 or 2 percent for the species of interest here. Small variations between samples within a group have been observed and are the primary source of the errors attached to the data.

Sampling

At the present time, data are available from 16 samples grouped in five sampling periods. Except for the production testing which occurred last June and July, no significant variation was observed within a sampling period. Therefore samples within a period have been averaged. Only these averages are presented. These averages are identified according to the mid-point of their sampling time following the detonation (December 10, 1967) as follows:

1st day samples: Four samples were obtained as a result of leakage through the cable conduits to the sealed annulus of the emplacement hole. While these samples were gathered about 1 day after the detonation, the actual time of their separation from the body of chimney gas is most certainly much shorter. They probably represent the chimney gas composition shortly after chimney collapse. Two were suitable for radiochemical analysis. However, these were 85 percent air. Therefore, the errors of the chemical analyses are magnified for the 15 percent of the sample deemed "cavity gas". In spite of this, the results do seem to provide useful information and to fit well with the main body of information obtained from the other groups of samples.

34th day samples: Seven samples were taken between 32 and 36 days after detonation when communication with the chimney by GB-ER[3] had been established. Five of these have been analyzed —two downhole samples and a surface sample taken before 3 × 10^5 ft^3 of gas was flared and one downhole and one surface sample after flaring. No significant differences in the results reported were seen between surface and downhole samples, or between samples prior to and following the flaring. The air correction of sample composition to obtain cavity gas composition was a few percent for these samples.

79th day samples: Of the four samples taken, results from one surface and one downhole sample following flaring of 4 × 10^6 ft^3 of gas are reported. As was the case of 34 days, no significant difference between samples was observed. Downhole sampling has therefore been eliminated. The air correction was only 1 percent for these samples.

134th day samples: Results of the two surface samples taken after 4 × 10^6 ft^3 of gas were flared are included in this report. No air correction was required.

203rd day samples: Data points at 203 days are taken from the first good sample obtained during the extended flow test. Approximately 5 × 10^6 ft^3 of gas had been flared prior to sampling. Samples were taken at intervals of 5 × 10^6 ft^3 or daily. Analytical results from six of these will be reported. No air correction was required for these samples.

Gasbuggy analytical results

For convenience and presentation the samples have been divided into two time periods. The first group is composed of those samples taken during the shut-in period prior to flow testing. Samples obtained during the flow testing comprise the second group. Somewhat arbitrary curves have been drawn through the data points.

Figure 5 (table 1) presents the observed changes in chemical composition of the cavity gas as a function of time. The effect of temperature equilibrium is clearly evident. Light gases predominate at early times, moving towards more complex gases as the chemical equilibrium shifts. Plotted across the lower portion of the graph is the total volume of gas with which the krypton-85 is mixed. Its constancy within analytical uncertainty is remarkable. Evidently equilibration of the cavity with formation pressure occurred quite rapidly and has been maintained throughout the shut-in period.

The total gas volume was obtained by dividing the total krypton-85 by the krypton-85/ft^3 NTP (normal temperature and pressure) determined

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[3] GB-ER, Gasbuggy-Emplacement re-entry hole, a post-detonation hole drilled directly through the original emplacement hole.

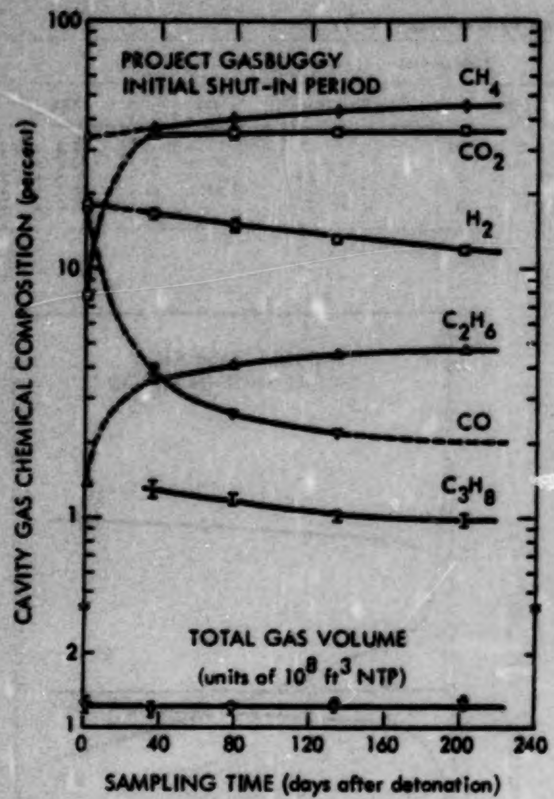

Figure 5. Chemical composition of cavity gas as a function of time after detonation

from radiochemical analysis of the samples. Total krypton-85 is estimated at 350 curies according to the anticipated performance of the nuclear explosive (*1*).

The rapid increase in CO_2 and the corresponding decrease in CO suggests that the water-gas reaction:

$$CO + H_2O \rightarrow CO_2 + H_2 \qquad (1)$$

reaches equilibrium at early times.

The gradual decrease in H_2 concentration appears to be due to the reaction:

$$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O \qquad (2)$$

which is observed to proceed slowly toward equilibrium throughout the sampling period. In addition, natural gas from the formation has entered the cavity to maintain constant pressure. Adding reactions (1) and (2) produces:

$$3H_2 + CO \rightarrow CH_4 + H_2O \qquad (3)$$

Note that CO_2 does not enter and is indeed constant over the major sampling period. H_2 and CO are being used up while methane is increasing. The observed increase in ethane concentration may be due to a reaction such as:

$$CH_4 + CO + 2H_2 \rightarrow C_2H_6 + H_2O \qquad (4)$$

The observed decrease in propane may or may not be significant. Variation such as that seen can be attributed to fractionation of the sample during the later sampling periods.

Another way to view the chemical data is in terms of totals of elements in the gas (figure 6). The total gas volume is plotted across the bottom of the figure to provide a base line. Above it, in the center of the figure are the concentrations of the elements of interest. Because of the constancy of the total gas volume, these curves represent totals equally well. The curves at the top of the figure are chemical composition in terms of atom percent.

This figure illustrates the trend toward more complex molecules by the chemical reaction processes coupled with the influx of formation gases

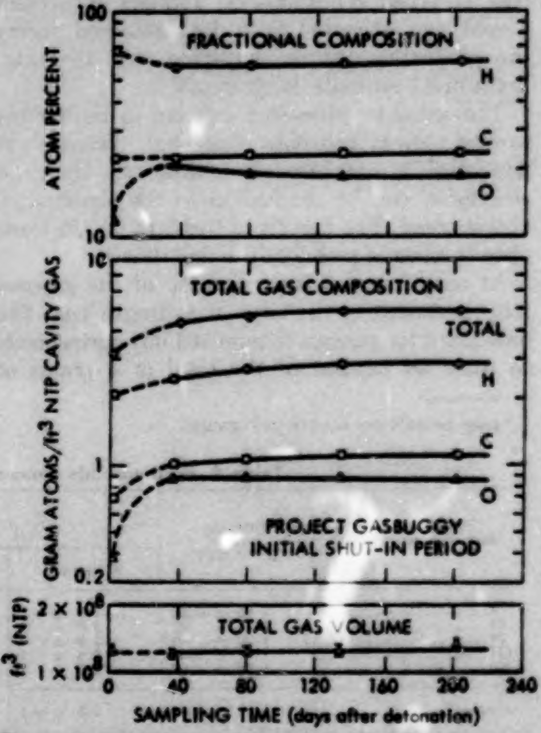

Figure 6. Elemental composition of cavity gas in a function of time after detonation

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Table 1. Chemical composition of Gasbuggy cavity gases

Sampling time (days after detonation)	Mole percent					
	H_2	CH_4	C_2H_6	C_3H_8	CO	CO_2
1	18.1 ± 0.6	34.0 ± 0.5	1.27 ± 0.02	—	17.1 ± 0.4	7.8 ± 0.2
38	16.8 ± .4	36.0 ± .8	3.80 ± .06	1.3 ± 0.1	3.9 ± .2	35.8 ± .5
79	15.2 ± 1.0	40.1 ± 2.0	4.1 ± .2	1.19 ± .04	2.6 ± .1	35.8 ± 1.6
134	13.2 ± .1	43.2 ± .7	4.5 ± .1	1.02 ± .05	2.20 ± .04	35.3 ± .7
203	12.0 ± .2	44.2 ± .7	4.7 ± .2	.97 ± .05	—	36.2 ± .7

to maintain a constant volume of gas within the chimney. Note that the fraction of hydrogen decreases even though the total number of hydrogen atoms increases early.

The increase in oxygen at early time is due to the production of CO_2 by the water-gas reaction (1). The decrease at late time can be accounted for by invoking reaction (3).

The radiochemical results for tritium in hydrogen, methane, and ethane, are plotted on figure 7 (table 2). Again, total gas volume is plotted along the base line for reference. The observed gas volume of 1.2 × 10^8 ft³ NTP can be contained in 2.1 ± 0.1 × 10^6 ft³ void at 150°F and 950 psig[4] (the observed conditions on January 23). Such a void was estimated from data obtained during the production testing, implying that the total krypton-85 estimate is reasonable.

The actual krypton-85 data seem to be moving toward lower concentrations but because of analytical errors associated with the data no conclusion can be reached as to the significance of this trend. The best fit to the data within these uncertainties is probably the line shown.

At early times a large fraction of the gaseous tritium existed in the form of hydrogen gas. The data point for gaseous trituim at 1 day corresponds to some 30 percent of the total of 4 grams of

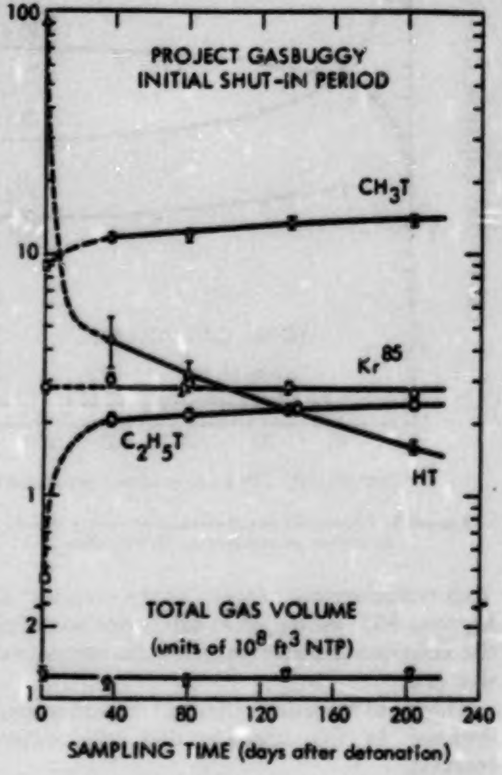

Figure 7. Radionuclide concentrations in cavity gas as a function of time after detonation

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[4] psig–pounds per square inch gauge.

Table 2. Radionuclide concentration in Gasbuggy cavity gases

Sampling time (days after detonation)	Total gas volume (10^8 ft³ NTP)	Radionuclide concentration[a] (μCi/ft³ of cavity gas)				
		Krypton-85	HT	CH_3T	C_2H_5T	Total tritium
1	1.25 ± 0.08	2.8 ± 0.2	91 ± 1	8.9 ± 0.1	0.45 ± 0.01	100 ± 1
38	1.17 ± .07	3.0 ± .2	4.4 ± 1.1	11.7 ± .1	2.06 ± .09	18 ± 1
79	1.20 ± .05	2.9 ± .2	3.1 ± .5	12.0 ± .7	2.15 ± .08	17 ± 1
134	1.24 ± .05	2.8 ± .1	2.3 ± .1	13.6 ± .2	2.3 ± .1	18 ± 1
203	1.28 ± .07	2.7 ± .1	1.6 ± .1	13.9 ± .7	2.4 ± .1	18 ± 1
Average	1.23 ± 0.04	2.8 ± 0.1				[b](18 ± 0.5)

[a] Errors quoted are 1-standard deviation of the mean of averaged measurements.
[b] Average does not include the 1 day sample result.

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tritium assumed present in the post-shot chimney. During the first month the HT level dropped quite rapidly and continued to decline at a slower rate. Prior to the time re-entry of the chimney well was accomplished, tritiated methane became the principle contaminant of the chimney gas. About 5 percent of the total tritium remains gaseous at late times. Presumably the other 95 percent is in the form of water. No meaningful tritiated water results can be reported. Obtaining a representative sample of water in the chimney gas is extremely difficult. The actual numbers range from about a microcurie per cubic foot of cavity gas to 0.001 of that value, the variation being due primarily to dilution of the tritiated water in the sample by tritium-free water within the cavity and re-entry well casing coming from the overlying aquifers.

Iodine-131, a potential problem radionuclide at early times, was not seen in any of the samples. An upper limit of 10^{-3} μCi/ft^3 (NTP) of this radionuclide existing as a gas within the chimney appears conservative. No other radionuclides have been detected which would cause a problem at times longer than a few months. Argon-37 produced by neutron activation of the calcium in the rock is the only other radionuclide now prominent in the gas. Its initial concentration was about 120 μCi/ft^3 NTP. Due to its half-life (35.4 days) the argon-37 concentration is now less than that of krypton-85.

Analysis of a sample obtained from GB-2R[3] is not yet complete, but does indicate the presence of a small quantity of cavity gas in the formation out to at least 300 feet.

Changes in the concentrations of the tritiated species appear to follow the trends observed for chemical compositions, with the exception that the decrease of tritiated hydrogen is more marked than the corresponding decrease in hydrogen gas. Equilibrium reaction such as the water-gas reaction (1) provide a path whereby tritium can exchange with hydrogen in water, reducing the tritium concentration. The overall effect is that the ratio of tritium to hydrogen tends to equalize in all hydrogen containing species participating in the exchange. The degree to which this is observed depends on the exchange rate.

The rapid initial decrease in HT concentration can therefore be explained using the water-gas reaction:

$$HT + CO_2 \rightarrow HTO + CO \qquad (5)$$

and reactions such as (2) and (4) can be used to explain the observed increases in tritiated methane and ethane.

In figure 8, specific activities are compared for the tritiated species. These curves demonstrate the trend toward a uniform tritium to protium ratio. The HT/H_2 ratio is seen to drop quite rapidly as the water-gas reaction approaches equilibrium and to change slope as the slower chemical reactions begin to dominate. The rapid decrease observed indicates that the T/H in cavity water was quite low, and is consistent with the production of CH_4 and C_2H_6 by reactions such as (2) or (4).

The fact that both the CH_3T and C_2H_5T curves appear to be flat over the entire sampling period is not contradictory. They are being produced by

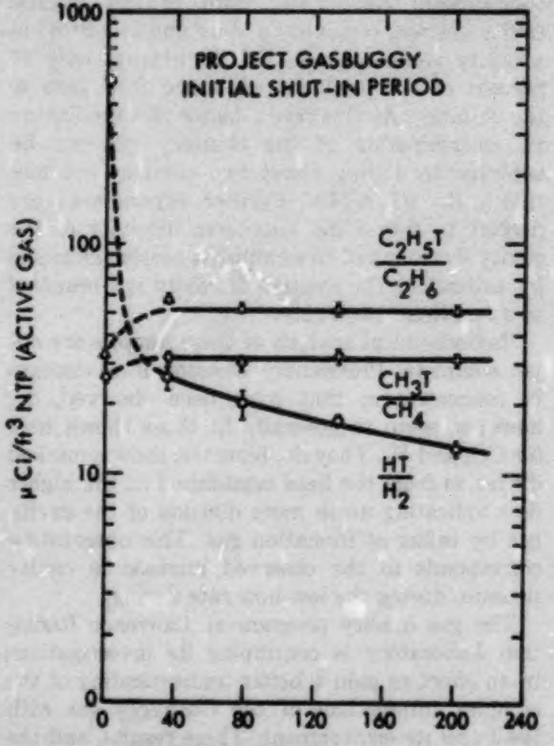

Figure 8. Specific activities of tritiated species as a function of time

hydrogen of nearly comparable specific activity. In fact, the samples at 134 days show very nearly the classical 1:2:3 ratio for the three curves. Presumably the eventual downward trend should appear when the HT is further reduced by exchange with water. The fact that exchange equilibrium existed at 134 days and that the HT/H_2 ratio is still decreasing may imply entry of non-tritiated water into the chimney.

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[3] Second Gasbuggy re-entry hole drilled about 300 feet from GB-ER.

Isotopic effects are not considered here but would also tend to reduce the tritium as elemental hydrogen in favor of water at low temperatures.

Changes in chemical composition of the gas during the 11-day flow test which occurred during June–July 1968 are plotted on figure 9. Logarithmic increases with flow for components of natural gas are complimented by corresponding decreases for gases solely of cavity origin. Results plotted cover the flaring period at 5×10^6 ft^3 per day nominal flow.

The produced gas is nearly like cavity gas in composition. About one third of the original cavity gas was removed by dumping two fifths of a cavity volume of gas. On the average only 17 percent of the produced gas came from outside the chimney. At this rate a factor of 10 reduction in contamination of the chimney gas can be achieved by flaring about two chimney volumes (2.5×10^8 ft^3 NTP). Further experiments are needed to define the long-term behavior of the cavity flushing and to establish a consistent model for estimating the fraction of cavity gas removed as a function of flow rate.

Radiochemical analysis of these samples are not yet complete. Preliminary assessment of changes in concentration that have been observed, do, however, seem to generally fit those shown here for CO_2 and H_2. They do, however, show a marked deviation from the lines established at the higher flow indicating much more dilution of the cavity gas by influx of formation gas. This observation corresponds to the observed increase in cavity pressure during the low-flow rate flaring.

The gas quality program at Lawrence Radiation Laboratory is continuing its investigations in an effort to gain a better understanding of the complex interactions of the Gasbuggy gas with itself and its environment. These results, and the interpretations which can be drawn from them, will be publicly available in the future.

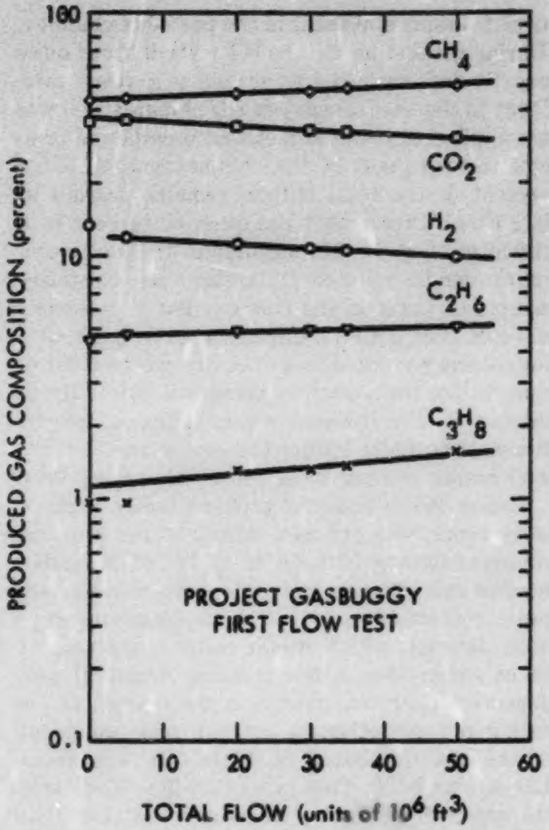

Figure 9. Changes in chemical composition of gas during 11-day flow test in June–July 1968

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The authors wish to acknowledge the assistance of Mr. R. Crawford of the Lawrence Analytical Chemistry Group who performed the chemical analysis by mass spectrometry.

REFERENCE

(*1*) KORVER, J. A. and D. E. RAWSON. Gasbuggy post-shot investigations in GB-ER, UCRL-50425. University of California, Livermore, Calif. (April 19, 1968).

Radioecological Surveillance of the Waterways Around a Nuclear Fuels Reprocessing Plant[1]

N. I. Sax, Paul C. Lemon, Allen H. Benton, and *Jack J. Gabay*[2]

A 3-year study of the aquatic ecosystem around a nuclear fuels reprocessing plant, located in western New York State, has been conducted to find and evaluate natural indicators of environmental contamination. The study covered preoperational and early post-operational phases. The ecological vectors selected for study were algae, silt, and fish, all from Cattaraugus Creek and its tributaries. Samples were collected at several points upstream and downstream from the plant effluent and quantitatively analyzed by gamma-ray spectrometry. All vectors analyzed indicated process of uptake and concentration of ruthenium-rhodium–106, cesium-137, cesium-134, and/or zirconium–niobium–95, and sometimes cobalt–60.

In addition, the concept of using natural indicators not native to the streams under study was tested by translocating fresh water clams from Chautauqua Lake, 60-miles southwest of the site, and placing them in the streams around the plant. The clams not only thrived in their new environment but upon analysis showed definite interaction by concentration of the above radioisotopes with the shells showing approximately twice the radioactivity of the soft parts of the clams. This concept might prove to be a sensitive indicator of environmental contamination.

In April 1966, the world's first commercial nuclear fuels reprocessing plant, located in the southwestern part of New York State, became operational. Prior to and since then, the Radiological Sciences Laboratory of the Division of Laboratories and Research, New York State Department of Health, with the cooperation of the State University of New York, has been conducting an ecological study of the effect on the aquatic ecosystems in that area with a view to finding the most suitable vectors as natural indicators of environmental contamination.

Description of sources

The facility is a multipurpose plant capable of processing any type of nuclear fuel element from which the fuel can be reduced to a nitric acid solution. The baseline process is a Purex solvent-extraction method designed for processing, at a capacity of 1,000 kg/day of uranium enriched <3 percent in the form of UO_2 or uranium metal. Fuels must be cooled 150 days after removal from a reactor before they can be processed (*1*). In addition, a burial site, operational since 1963, is maintained for the storage of high, intermediate, and low-level radioactive wastes from the plant and offsite users.

Study area

Study of the aquatic ecosystem centers on two waterways flowing through and around the reprocessing plant site (figure 1). Buttermilk Creek flows through the site in the southeast to northwest direction and empties into Cattaraugus Creek just outside the extreme northwest corner of the site. Cattaraugus Creek flows in a westerly direction and, after many convolutions, eventually empties into Lake Erie. Both streams are fed by many tributaries. The only important tributary, considering radionuclide inventory in the streams, is Erdman Brook, which serves as a receptor for runoff from the burial site and effluent discharge from the reprocessing plant.

The physical and chemical characteristics of a portion of Cattaraugus Creek were studied to determine some of the ecological conditions to which organisms living in the stream must adapt in order to survive. Determination of the oxygen

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[1] This investigation was supported by U.S. Public Health Service Grant RH 412, National Center for Radiological Health.

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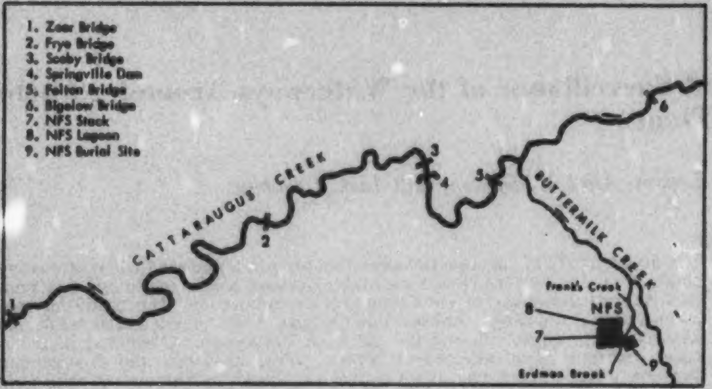

Figure 1. Waterways around the reprocessing plant, burial site, and sampling stations

and carbon dioxide served as a measurement of the relative extent of organic pollution and permitted evaluation of the distribution of organisms in the stream. This knowledge would be of value in planning future experiments. Quantitative data on stream flow, dissolved oxygen concentrations, and carbon dioxide concentrations were taken at Felton Bridge (figure 1) during the summer of 1967. Data were secured by standard methods (*2*); surface velocity was determined with a floating object and stream flow was determined by using the formula: $R = W D a V$

where R = volume in ft^3/sec;
W = width in ft;
D = average depth in ft;
a = correction factor for substrate;
and, V = surface velocity in ft/sec.

During a period of average flow, the rate was estimated at 54,000 gallons/minute. After a heavy rain, the flow was estimated at 132,500 gallons/minute, indicating the rather wide variation in flow which the creek may undergo. Further, the latter estimate is not representative of a maximum flow since it would have been quite impossible to make the necessary measurements during peak flow following a heavy rain. It is clear that wide fluctuations in flow present one of the major ecological factors of this particular creek, and one to which organisms living in the creek must adapt.

Oxygen and carbon dioxide determinations were also made at the Felton Bridge sampling point. These parameters were determined by standard methods described by Welch (*3*). In swift current the stream contained 4–5 ppm dissolved oxygen and 2–3 ppm of carbon dioxide. Backwaters were found to contain 2–3 ppm of dissolved oxygen and 10–11 ppm of carbon dioxide.

Sampling and analytical methods

Study of the streams around the reprocessing plant permits a meaningful relationship to be derived concerning the dispersion of radioactivity released into the stream and concentration by various organisms residing therein. In reality, there are two streams plus tributaries which must be considered as one system. Sampling points on Erdman Brook and Buttermilk Creek upstream from the plant, and on Cattaraugus Creek upstream from the confluence with Buttermilk Creek are considered control points. All downstream sampling points are considered reaction points.

A simple ecological chain, consisting of water, algae, silt, and fish, was set up, and such samples were routinely collected at the designated sampling sites. Analysis by gamma-ray spectrometry offered unique advantages in that quantitative information on the presence of several radionuclides could be obtained from a single sample with little prior processing.

Liquid samples were analyzed without processing except for transfer to a counting container. Solid samples were blended before transfer. The standard counting container was a 2-liter Marinelli beaker. Samples up to 300 ml for liquids (300 g for solids) were accommodated by placing them on the top of the crystal. Integral-line NaI (Tl) crystal detectors, 3 by 3 inches, were used in conjunction with multichannel analyzers operated in the 256 channel mode. Standard readouts were typewriter, X–Y plotter, and punched paper tape, which was converted to punched cards for computerization. Data were quantitated by using inverted matrix techniques. Routinely, standard matrices were prepared for each sample type. However, all spectra were visually examined and special matrices were prepared to accommodate nonroutine spectra.

The occurrence of complex spectra containing radionuclides whose photopeaks coincide or overlap makes electronic resolution extremely difficult. The presence of both zirconium–niobium–95 and cesium–134 in our samples was anticipated; cesium–134 has two photopeaks (0.605 and 0.796 MeV) which coincide with photopeaks for cesium–137 (0.662 MeV) and zirconium–niobium–95 (0.724, 0.757 and 0.765 MeV). Significant concentrations of any of these nuclides can effectively mask or confuse the identity of others.

The presence of both zirconium–niobium–95 and cesium–134 in the aquatic environment was qualitatively confirmed in silt samples by chemical isolation of radiozirconium and radiocesium followed by gamma-ray spectral analysis of each fraction. Semiquantitative analysis of the data indicated that each radionuclide was present in approximately equal concentration. No attempt was made to relate the fractionation ratios to other silt samples, or to extrapolate to other sample types such as algae or fish. Therefore, all such data are reported as ^{95}ZrNb–^{134}Cs, indicating that either or both of these radionuclides are present.

Results and discussion

Water

Radioactivity from liquid effluents released directly into the stream will tend to be dispersed and diluted. Although no significant radionuclide concentration was anticipated, stream water was sampled and analyzed regularly to provide a frame of reference for other ecological samples. Results of radioactivity in the streams are given in table 1.

Algae

Algal samples were collected at a number of points along the stream during the summer of 1967 and analyzed (table 2). In general, the radionuclide concentration decreased as a function of distance from the source (figure 2).

Algae are well known for their ability to concentrate certain radionuclides. Lackey (*4*) found that the gross count rate for *Oedogonium* to be 104 times that for the surrounding water. Blinks and Nielsen (*5*) determined that *Hydrodictyon* may accumulate potassium to 4 × 10^{3} times that in the surrounding water. Concentration of strontium-90 by green algae and by the water flea (*Daphnia*), using green algae as a food source has been reported (*6–8*). Williams and Swanson (*9*)

Table 1. Radioactivity in streams around Nuclear Fuel Services site, 1965–1967

Sampling station	Collection period	Radionuclide concentration (pCi/liter)			
		^{106}Ru-Rh	^{137}Cs	^{95}Zr-Nb-^{134}Cs	^{60}Co
Control points:					
Buttermilk Creek, upstream	12/65– 3/66[a]	[b]0 (26)	5 (26)	2 (26)	0 (26)
	6/67–12/67	40 (6)	3 (6)	0 (6)	1 (6)
Bigelow Bridge	12/65– 3/66[a]	0 (11)	5 (11)	1 (11)	0 (11)
	4/66–12/66	0 (14)	6 (14)	3 (14)	0 (14)
	6/67–11/67	2 (6)	5 (6)	0 (6)	2 (6)
Erdman Brook upstream[c]	5/67–12/67	150 (19)	10 (19)	0 (19)	20 (19)
Reaction points:					
Buttermilk Creek, downstream	12/65– 3/66[a]	0 (3)	1 (3)	6 (3)	0 (3)
	6/67–12/67	1,000 (18)	100 (18)	10 (18)	10 (18)
Springville Dam	12/65– 3/66[a]	0 (11)	1 (11)	0 (11)	0 (11)
	4/66–12/66	0 (22)	10 (22)	4 (22)	0 (22)
	5/67– 9/67[d]	100 (3)	10 (3)	0 (3)	4 (3)

[a] Preoperational samples, taken before radioactivity was introduced into environment by NFS.

[b] Numbers in parentheses indicate number of samples averaged.

[c] Erdman Brook, upstream is not truly a control point. It is upstream of the point where plant effluents are discharged into the brook; but is downstream to run-off from the burial site. It is therefore, an indicator of the contribution of the burial site to the radionuclide inventory in the stream.

[d] Continuous monthly composite.

Table 2. Average radionuclide concentration in algae, 1967

Sampling station	Collection period	Radionuclide concentration (pCi/kg wet weight)			
		^{106}Ru-Rh	^{137}Cs	^{95}Zr-Nb-^{134}Cs	^{60}Co
Control point:					
Bigelow Bridge	7/67–8/67	[a]7 (9)	15 (9)	50 (9)	70 (9)
Reaction points:					
Buttermilk Creek, downstream	8/67	344,000 (1)	50,400 (1)	9,100 (1)	1,100 (1)
Felton Bridge	7/67–8/67	54,000 (2)	69,900 (2)	13,400 (2)	700 (2)
Springville Dam	7/67–8/67	45,600 (6)	23,400 (6)	5,700 (6)	350 (6)
Frye Bridge	7/67	10,200 (3)	5,000 (3)	1,350 (3)	180 (3)
Zoar Bridge	7/67	1[illegible],800 (2)	5,100 (2)	1,200 (2)	190 (2)

[a] Numbers in parentheses indicate number of samples averaged.

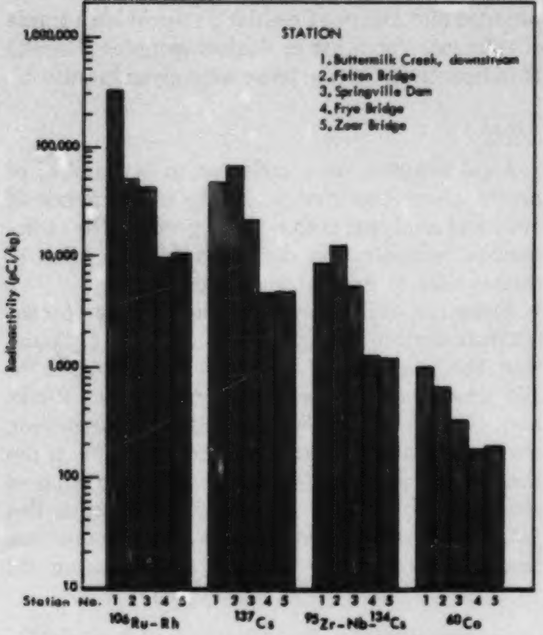

Figure 2. Concentration of various radionuclides in algae as a function of distance from the source

found concentration of cesium–137 by *Rhizoclonium* to be 1.5×10^3 times that of its environment. Williams (*10*) reported that *Chlorella* concentrated radiocesium 46 to 59 times that in the surrounding medium. Interestingly, dead *Chlorella* cells showed a similar concentrating ability.

It would thus appear that a period of algal bloom, followed by death and decay of the algae, might cause a very significant concentration of radiocesium and might produce a rather high level of radioactivity on the bottom. Although the upper levels may quickly be decontaminated, the bottom fauna is exposed to a rapidly increasing level of concentration, mostly bound cesium, in the dead organisms and detritus on the bottom.

The fact that algae might retain high radionuclide levels even after death and settling suggests that the concentration of such materials in silt might be unusually high. It is also established that adsorption of radioactive particulates may take place on tiny silt particles in the water, and that settling out of these particles will then concentrate the radionuclides concerned. Studies on bottom dwelling organisms in the Clinch River and White Oak Creek indicate that such organisms receive an average dose 20 to 1,000 times that from naturally occurring radiation (*11*).

Silt

Samples of stream bottom silt were collected at all the water sampling points as well as two additional sites. Collection dates extend from August 1966 to October 1967. Silt radioactivity (table 3) tends to show, again, the general decline with increased distance from the point of introduction (figure 3).

The contribution from burial site run-off to the stream inventory (table 4) is of particular interest since effluent discharge from the reprocessing plant and run-off from the burial site are apparently unrelated. The water and silt data from Erdman Brook, upstream or plant effluent discharge but downstream from the burial site runoff, and Buttermilk Creek, downstream from plant effluent discharge (figure 1) provide a means for evaluation. Dilution factors, due to the larger amount of water in Buttermilk Creek, are not known, thereby tending to make the radionuclide contribution to the stream inventory from the burial site, as based on the water data, suspect. However, these dilution factors should not significantly influence

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Table 3. Radionuclide deposition in stream bottom silt, 1966–1967

Sampling station	Collection period	Radionuclide concentration (pCi/kg wet weight)			
		^{106}Ru-Rh	^{137}Cs	^{95}Zr-Nb-^{134}Cs	^{60}Co
Control points:					
Buttermilk Creek, upstream	8/66–12/66	[a]6,700 (2)	420 (2)	320 (2)	110 (2)
Bigelow Bridge	9/66–10/67	220 (10)	70 (10)	50 (10)	5 (10)
Erdman Brook, upstream[b]	12/66	44,100 (1)	16,500 (1)	5,500 (10)	1,400 (1)
Reaction points:					
Buttermilk Creek, downstream	8/66– 8/67	220,000 (7)	115,000 (7)	120,000 (7)	8,000 (7)
Felton Bridge	9/66–10/67	53,400 (10)	62,000 (10)	12,800 (10)	690 (10)
Springville Dam	9/66–10/67	45,700 (9)	28,800 (9)	7,400 (9)	470 (9)
Frye Bridge	7/67–10/67	36,700 (7)	34,100 (7)	4,500 (7)	380 (7)
Zoar Bridge	9/66–10/67	15,100 (12)	5,300 (12)	1,700 (12)	120 (12)

[a] Numbers in parentheses indicate number of samples averaged.

[b] Erdman Brook is upstream of the point where plant effluents are discharged into the brook; but is downstream to run-off from the burial site. It is, therefore, an indicator of the contribution of the burial site to the radionuclide inventory in the streams.

the radionuclide adsorption onto silt. Table 4 was prepared to compare the data from tables 1 and 3. An estimated percent contribution is offered to assess the contribution of the burial site to the stream inventory.

Although these data are quite preliminary, some relationships are apparent. The percent contribution from the burial site for both water and silt is relatively consistent with respect to ruthenium–106 and cesium–137 activity. The contribution due to the ^{95}ZrNb–^{134}Cs pair is appreciably smaller than that due to the other radionuclides, implying that one of the pair may not be present in the run-off from the burial site.

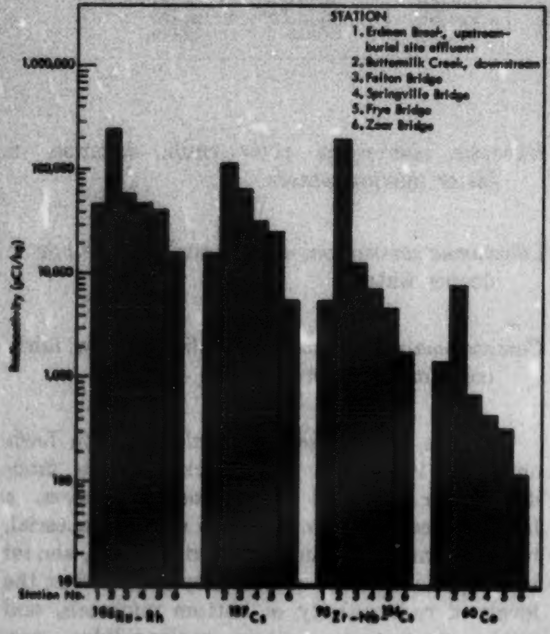

Figure 3. Deposition of various radionuclides on stream bottom silt as a function of distance from the source

Fish

Fish can be an important ecological vector since they, too, are known to concentrate certain radionuclides. Concentration of radiostrontium by freshwater fish has been reported (*12–13*). Kolehmainen et al. (*14*) reported that cesium–137 levels in fish in Finland were inversely related to conductivity of the water. Recent studies on Columbia River fish indicate that they concentrate phosphorus–32 and zinc–65 (*15-16*).

Fish samples were taken by net and prepared for analysis as they were captured without sorting. This provided an ample volume for counting (table 5).

It is interesting to note that preoperational fish samples collected at downstream points indicated significant radionuclide concentration while those at upstream points did not. Since these fish were collected before the reprocessing plant became operational (but after operation of the burial site), contamination from the burial site must be considered the likely source. This again emphasizes the contribution of the burial site to the stream inventory. Of the post-operational samples, all indicated concentration of cesium–137 and probably cesium–134, while some showed concentration of ruthenium–rhodium–106 and/or cobalt–60 as well. This may well be a function of specific species and pointed to the need for a more detailed study of individual species present in the streams.

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Table 4. Radionuclide contribution of burial site to stream inventory 1965–1967

Sample type	Sampling point	Radionuclide concentration[a] (pCi/liter or kg wet weight)			
		^{106}Ru-Rh	^{137}Cs	^{95}Zr-Nb-^{144}Ce	^{60}Co
Water	Erdman Brook upstream	150	10	0	20
	Buttermilk Creek, downstream	1,000	100	10	10
Percent contribution		15.0	10.0	0	>100
Silt	Erdman Brook, upstream	44,100	16,500	5,800	1,400
	Buttermilk Creek, downstream	226,000	115,000	120,000	8,000
Percent contribution		19.5	14.3	4.8	17.5

[a] Units are pCi/liter for water samples, pCi/kg for silt samples.

Table 5. Radionuclide uptake by stream fish, 1965–1967

Sampling station	Collection period	Radionuclide concentration (pCi/kg wet weight)			
		^{106}Ru-Rh	^{137}Cs	^{95}Zr-Nb-^{144}Ce	^{60}Co
Control points:					
Buttermilk Creek, upstream	10/27/65[a]	0±20[b]	80±20	30±15	0±15
Bigelow Bridge	10/27/65[a]	0±20	20±15	5±10	0±10
Reaction points:					
Buttermilk Creek, downstream	10/27/65[a]	0±20	1,700±130	240±30	50±20
	5/20/66	0±20	4,000±250	6,100±300	130±30
	8/1/67	23,900±2,400	31,100±1,800	7,000±500	350±75
Felton Bridge	10/27/65[a]	0±20	460±50	240±30	50±20
	7/5/67	310±350	2,300±160	530±60	7±20
	8/23/67	90±230	410±70	80±30	0±15
	8/24/67	980±280	910±95	340±40	0±15
	8/24/67	370±300	440±240	60±110	0±15
	8/25/67	4,300±690	3,300±260	580±70	20±30
Frye Bridge	7/30/67	4,400±350	1,400±130	250±40	30±30

[a] Preoperational samples.
[b] 2σ counting error.

Fish are varied in their mode of life. Consequently, accumulation of radionuclides by any one group can be quite different from that by another. There are, however, some facts regarding accumulation that apply to fish generally. Uptake of elements may take place from water directly or from the ingestion of food containing concentrated amounts. The manner of uptake of elements by the different types of fish needs considerable study.

Fortunately, there are several common fish species in the streams which can be caught in fair numbers, including some bottom feeders. Five species were deemed abundant enough to be suitable for repeated collection over time:

Notropis cornutus—common shiner abundant in the creek itself.

Semotilus atromaculatus—horned dace, abundant in the backwaters and pools.

Hybopsis micropogon—river chub, common in faster moving waters.

Catostomus commersoni—white sucker, common in deeper waters.

Campostoma anomalum—stoneroller minnow, fairly common in the stream.

Of these, *Campostoma anomalum*, which feeds on algae it scrapes from rocks with a modified lower lip, and *Catostomus commersoni*, a bottom feeder, which sucks up organic material, bottom plants and animals, and detritus, should be of special interest in that they must reflect the levels of radioactivity of bottom materials, and might concentrate certain radionuclides very effectively.

Table 6. Accumulation of radionuclides by translocated clams, 1967

Sampling station	Structure	Radionuclide concentration (pCi/kg wet weight)			
		^{106}Ru-Rh	^{137}Cs	^{95}Zr-Nb-^{144}Ce	^{60}Co
Chautauqua Lake (untreated control)	Shell	0±20[a]	0±20	0±20	0±20
	Soft body	0±20	0±20	0±20	0±20
Buttermilk Creek	Shell	24,800±1,700	5,800±380	1,400±110	170±30
	Soft body	11,900±940	2,400±200	500±60	20±30
Felton Bridge	Shell	4,700±450	550±70	140±30	20±30
	Soft body	6,000±650	480±280	190±100	20±110

[a] 2σ counting error.

Clams

Shellfish have the ability, alone or by means of their aquatic food sources, to concentrate certain stable elements and radionuclides far above the ambient concentration in the water environment. The filter-feeding habit of the clam makes it an excellent biological indicator and adapts it admirably for food chain investigations.

Clams have been reported to concentrate cobalt-60 (*17–18*); iron-59 (*18*); zinc-65 (*19–21*); strontium-90 (*22*), particularly in the calcareous shell (*23*); cesium-137 (*23–24*); and manganese-54 (*25–26*).

Clams are not native to the streams around the reprocessing plant. During the summer of 1967, about 150 freshwater clams (*Lampsilis ventricosa* and *L. siliquoidea*) were collected from Chautauqua Lake, about 60 miles southwest of the plant. They were divided into three lots, one of which was immediately killed and separated into shells and soft parts to be used as controls. One set was placed in Buttermilk Creek about 0.5 miles downstream from the plant. Another set was placed in Cattaraugus Creek at Felton Bridge about 1 mile downstream from the plant. They appeared to thrive in their new habitat and at the end of the summer they were removed from the streams, separated into shells and soft parts and analyzed by gamma-ray spectrometry (table 6). Definite accumulation of radionuclides is indicated.

Conclusions

Our efforts have been largely "range finding" in nature, and much time was spent in becoming familiar with the area and determining the abundance of aquatic life present in the streams.

Preliminary data have been presented to demonstrate the ability of the ecological vectors selected to concentrate radionuclides from their environment. However, they are, as yet, too sparse to permit meaningful relationships to be derived.

Aquatic life probably represents the most rewarding area for ecological assessment of the effects of the reprocessing plant. The translocation of clams, as a biological indicator, holds great promise and should be further pursued. Silt, algae, clams, and fish, particularly bottom feeders such as *Campostoma anomalum* and *Catostomus commersoni* taken in conjunction with each other at periodic intervals might establish a meaningful relationship between radioactivity in algae and silt and concentration by fish and clams.

It appears that enough natural indicators of environmental contamination are available to set up a simple and effective means to maintain surveillance and evaluate the effects of the reprocessing plant upon the stream system.

It remains to establish more exactly the rate and extent of interaction of these indicators to the various radionuclides.

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SECTION I. MILK AND FOOD

Milk Surveillance, March 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

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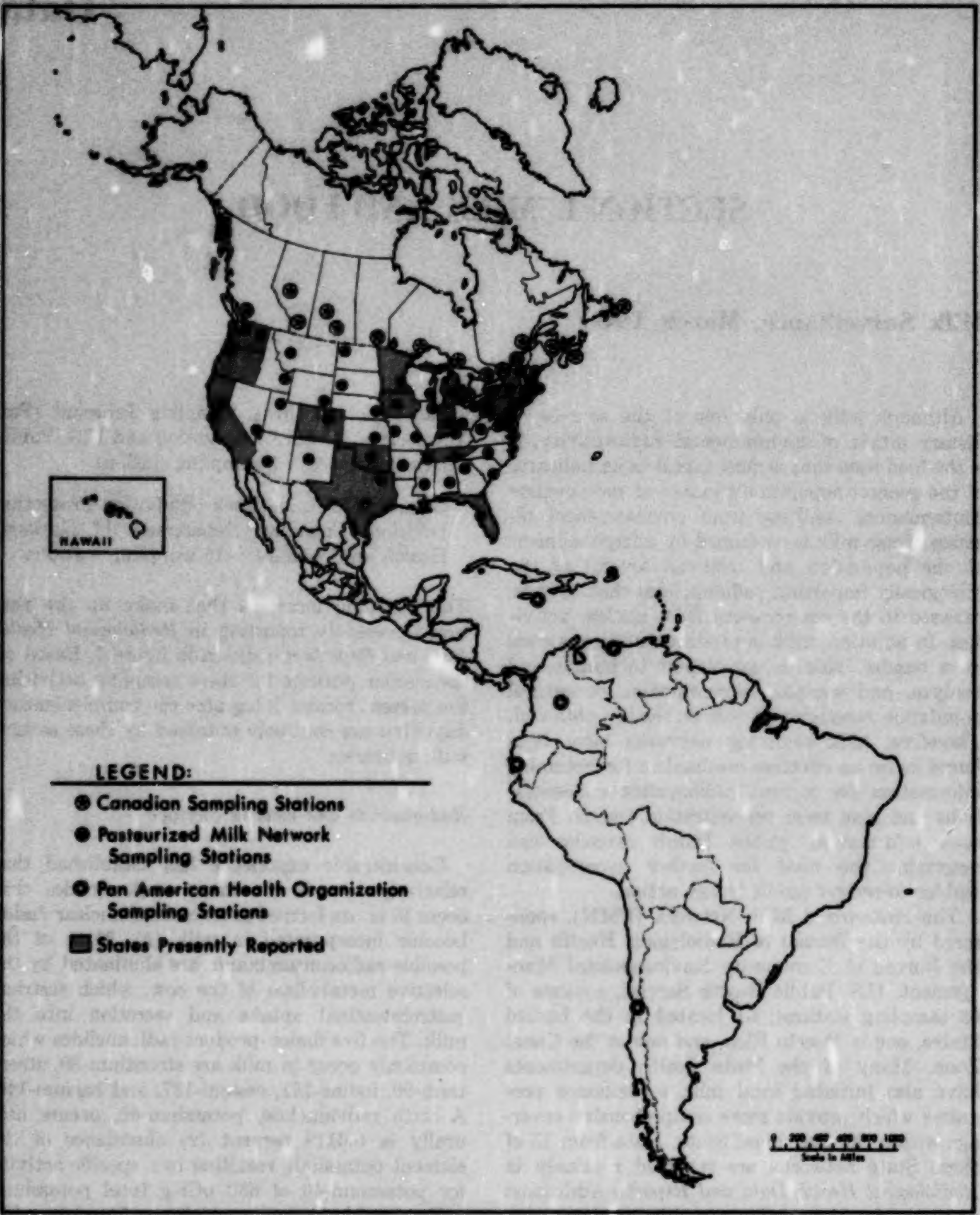
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Health Organization Sampling Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

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metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20 — 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over time periods and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation will also reflect whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (3). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (3). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviations
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8*, *9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (3).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assump-

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/yr)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c].5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c].5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,000	0-300	300-3,000	3,000-30,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

tions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1- or 2- year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first year total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000
Strontium-90	Bone marrow			[c]91,000
Cesium-137	Whole body			[c]730,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

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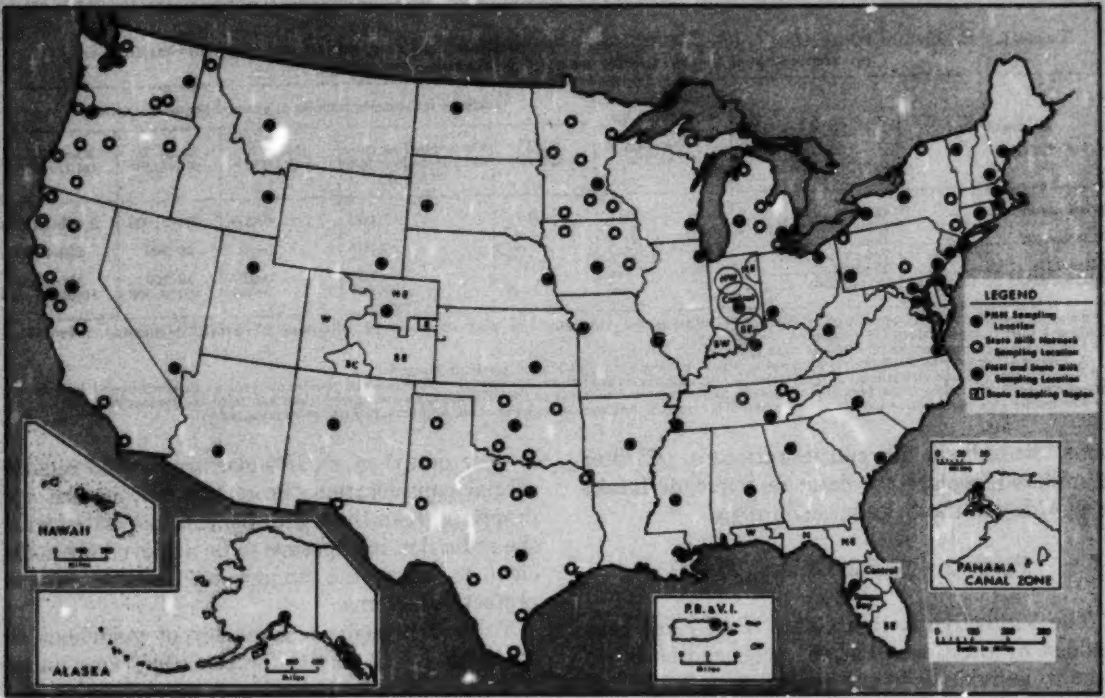

Figure 2. State and PMN milk sampling locations in the United States

the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137, for March 1969 and the 12-month period, April 1968 to March 1969. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have

Table 3. Concentration of radionuclides in milk for March 1969 and 12-month period, April 1968 through March 1969

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	6	8	0 (4)	0	12 (4)	14
Alaska:	Palmer[c]	P	6	6	0 (3)	0	12 (3)	13
Ariz:	Phoenix[c]	P	0	1	0 (4)	0	0 (4)	1
Ark:	Little Rock[c]	P	19	20	0 (5)	0	19 (5)	20
Calif:	Sacramento[c]	P	0	1	0 (4)	0	0 (4)	3
	San Francisco[c]	P	2	1	0 (4)	0	0 (4)	2
	Del Norte	P	18	19	0	0	23	21
	Fresno	P	0	0	0	0	0	3
	Humboldt	P	6	4	0	0	0	11
	Los Angeles	P	3	1	0	0	0	4
	Mendocino	P	5	2	0	0	0	4
	Sacramento	P	3	2	0	0	11	5
	San Diego	P	3	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	6
	Shasta	P	3	3	0	0	0	4
	Sonoma	P	4	2	0	0	0	4
Colo:	Denver[c]	P	3	5	0 (4)	0	0 (4)	5
	West	R	(d)		(e)	(e)	(e)	5
	Northeast	R	(d)		NS	(e)	NS	(e)
	East	R	(d)		NS	(e)	NS	(e)
	Southeast	R	(d)		(e)	(e)	(e)	(e)
	South Central	R	(d)		NS		NS	(e)
Conn:	Hartford[c]	P	6	9	0 (4)	0	8 (4)	12
	Central	P	6	8	0 (4)	0	4	9
Del:	Wilmington[c]	P	8	10	0 (4)	0	5 (4)	9
D.C:	Washington[c]	P	7	9	0 (4)	0	0 (4)	6
Fla:	Tampa[c]	P	8	8	0 (4)	0	39 (4)	63
	West	R	16	13	0	3	19	24
	North	R	16	14	0	0	18	32
	Northeast	R	10	9	0	2	64	81
	Central	R	9	9	0	1	90	84
	Tampa Bay area	R	9	8	0	0	41	71
	Southeast	R	10	9	0	0	78	111
Ga:	Atlanta[c]	P	11	14	0 (4)	0	18 (4)	20
Hawaii:	Honolulu[c]	P	2	4	0 (4)	0	0 (4)	2
Idaho:	Idaho Falls[c]	P	6	6	0 (4)	0	7 (4)	9
Ill:	Chicago[c]	P	8	9	0 (5)	0	6 (5)	10
Ind:	Indianapolis[c]	P	7	8	0 (4)	0	11 (4)	7
	Northeast	P	5	11	0	0	5	11
	Southeast	P	3	10	0	0	15	14
	Central	P	4	9	0	0	10	10
	Southwest	P	6	9	0	0	15	13
	Northwest	P	8	10	0	0	15	13
Iowa:	Des Moines[c]	P	7	6	0 (4)	0	3 (4)	4
	Iowa City	P	7	7	0 (2)	0	13 (2)	8
	Des Moines	P	6	6	0	0	3 (4)	4
	Spencer	P	6	6	0	0	20	6
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	9	8	0 (4)	0	2 (4)	4
Ky:	Louisville[c]	P	10	12	0 (3)	0	13 (3)	7
La:	New Orleans[c]	P	16	19	0	0	4	22
Maine:	Portland[c]	P	10	12	0 (5)	1	16 (5)	27
Md:	Baltimore[c]	P	6	10	0 (4)	0	7 (4)	8
Mass:	Boston[c]	P	10	12	0 (4)	0	20 (4)	24
Mich:	Detroit[c]	P	8	9	0 (4)	0	14 (4)	11
	Grand Rapids[c]	P	11	11	0 (5)	0	17 (5)	15
	Bay City	P	NA		(e)	(e)	0 (5)	8
	Charlevoix	P	7	6	(e) (5)	(e)	15 (5)	10
	Detroit	P	5	5	(e) (4)	(e)	6 (4)	5
	Grand Rapids	P	7	6	(e) (5)	(e)	16 (5)	10
	Lansing	P	NA	4	(e) (2)	(e)	0 (2)	3
	Marquette	P	11	8	(e) (3)	(e)	28 (3)	27
	Monroe	P	3	3	(e) (3)	(e)	0 (3)	1
	Grand Haven	P	7	7	(e) (4)	(e)	8 (4)	6
Minn:	Minneapolis[c]	P	9	12	0 (4)	0	13 (4)	14
	Bemidji	P	16	16	0	0	19	25
	Mankato	P	9	6	0	0	11	0
	Rochester	P	8	9	0	0	0	0
	Duluth	P	NS	20	NS	0	NS	32
	Worthington	P	5	6	0	0	13	0
	Minneapolis	P	10	12	0	0	0	15
	Fergus Falls	P	7	10	0	0	0	11
	Little Falls	P	9	10	0	0	0	16
Miss:	Jackson[c]	P	11	16	0 (4)	0	9 (4)	16
Mo.:	Kansas City[c]	P	6	7	0 (4)	0	0 (4)	3
	St. Louis[c]	P	7	9	0 (4)	0	4 (4)	5
Mont:	Helena[c]	P	4	4	0 (3)	0	8 (3)	9
Nebr:	Omaha[c]	P	5	6	0 (4)	0	2 (4)	5
Nev:	Las Vegas[c]	P	3	1	0 (4)	0	0 (4)	2
N.H:	Manchester[c]	P	7	13	0 (4)	0	19 (4)	33
N.J:	Trenton[c]	P	8	10	0 (4)	0	14 (4)	11
N. Mex:	Albuquerque[c]	P	0	2	0 (5)	0	2 (5)	0

See footnotes at end of table.

ble 3. Concentration of radionuclides in milk for March 1969 and 12-month period, April 1968 through March 1969—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES—Continued								
N.Y:	Buffalo[c]	P	7	8	0 (4)	0	12 (4)	11
	New York City[c]	P	8	12	0 (5)	0	16 (5)	16
	Syracuse[c]	P	7	9	0 (4)	0	14 (4)	9
	Albany	P	5	8	0 (4)	0	0 (4)	0
	Buffalo	P	3	0	0 (2)	0	0 (2)	0
	Massena	P	9	11	10 (2)	0	21 (2)	22
	Newburg	P	8	12	0 (5)	0	0 (5)	0
	New York City	P	8	12	0 (5)	0	0 (5)	0
	Syracuse	P	8	9	0 (3)	0	0 (3)	0
N.C:	Charlotte[c]	P	13	15	0 (5)	0	11 (5)	12
N. Dak:	Minot[c]	P	9	11	0 (5)	0	8 (5)	14
Ohio:	Cincinnati[c]	P	8	9	0 (4)	0	5 (4)	6
	Cleveland[c]	P	8	10	0 (4)	0	9 (4)	9
Okla:	Oklahoma City[c]	P	3	9	0 (4)	0	8 (4)	7
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	5	7	0 (4)	0	7 (4)	13
	Baker	P	2	3	(e)	(e)	17	6
	Coos Bay	P	5	9	(e)	(e)	(e)	15
	Eugene	P	6	4	(e)	(e)	(e)	14
	Medford	P	4	3	(e)	(e)	30	12
	Portland composite	P	3	5	(e)	(e)	(e) (4)	8
	Portland local	P	6	5	(e)	(e)	(e) (4)	8
	Redmond	P	4	3	(e)	(e)	(e)	4
	Tillamook	P	7	7	(e)	(e)	0	26
Pa:	Philadelphia[c]	P	10	10	0 (4)	0	6 (4)	8
	Pittsburgh[c]	P	10	10	0 (5)	0	10 (5)	11
	Dauphin	P	8	8	0	0	19	19
	Erie	P	11	12	0	0	14	23
	Philadelphia	P	6	10	0	0	16	17
	Pittsburgh	P	8	12	0	0	19	16
R.I:	Providence[c]	P	8	11	0 (4)	0	15 (4)	19
S.C:	Charleston[c]	P	9	13	0 (4)	0	22 (4)	25
S. Dak:	Rapid City[c]	P	9	9	0 (5)	0	3 (5)	10
Tenn:	Chattanooga[c]	P	9	13	0 (5)	0	12 (5)	13
	Memphis[c]	P	7	11	0 (4)	0	2 (4)	6
	Chattanooga	P	11	11	0 (5)	0	17 (5)	17
	Clinton	P	12	14	0	0	19	19
	Knoxville	P	8	10	0 (2)	2	12 (2)	13
	Nashville	P	10	9	0 (2)	0	11 (2)	10
Tex:	Austin[c]	P	4	3	0 (5)	0	5 (5)	2
	Dallas[c]	P	7	8	0 (5)	0	4 (5)	7
	Amarillo	R	4	4	0	0	0	2
	Corpus Christi	R	NS	4	NS	0	NS	2
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	NS	6	NS	0	NS	7
	Harlingen	R	2	4	0	0	0	0
	Houston	R	NS	4	NS	0	NS	19
	Lubbock	R	NS	10	NS	0	NS	2
	Midland	R	NS	4	NS	0	NS	0
	San Antonio	R	NA	2	NA	0	NA	0
	Texarkana	R	8	11	0	0	15	18
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	NS	9	NS	0	NS	2
Utah:	Salt Lake City[c]	P	2	5	0 (4)	0	11 (4)	11
Vt:	Burlington[c]	P	9	10	0 (5)	0	14 (5)	10
Va:	Norfolk[c]	P	8	11	0 (4)	0	8 (4)	10
Wash:	Seattle[c]	P	7	8	0 (4)	0	9 (4)	20
	Spokane[c]	P	5	6	0 (4)	0	2 (4)	8
	Benton County	R	NA		0	0	0	6
	Franklin County	R	NS		NS	0	NS	0
	Sandpoint, Idaho	R	NA		0	0	14	25
	Skagit County	R	NA		0	0	11	14
W.Va:	Charleston[c]	P	10	12	0 (3)	0	18 (3)	7
Wisc:	Milwaukee[c]	P	7	7	0 (4)	0	15 (4)	12
Wyo:	Laramie[c]	P	6	4	0 (4)	0	14 (4)	11
CANADA								
Alberta:	Calgary	P	8	8	(d)		13	18
	Edmonton	P	6	8	(d)		10	19
British Columbia:	Vancouver	P	10	14	(d)		16	46
Manitoba:	Winnipeg	P	9	8	(d)		27	25
New Brunswick:	Fredericton	P	12	15	(d)		17	23
Newfoundland:	St. Johns	P	13	20	(d)		20	40
Nova Scotia:	Halifax	P	6	11	(d)		14	22
Ontario:	Ft. William	P	14	16	(d)		29	32
	Ottawa	P	10	9	(d)		15	18
	Sault Ste. Marie	P	16	15	(d)		31	34

See footnotes at end of table.

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Table 3. Concentration of radionuclides in milk for March 1969 and 12-month period, April 1968 through March 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
Ontario:	Toronto	P	7	5	[d]		16	15
	Windsor	P	6	6	[d]		34	14
Quebec:	Montreal	P	5	9	[d]		17	21
	Quebec	P	8	12	[d]		21	20
Saskatchewan:	Regina	R	6	7	[d]		12	17
	Saskatoon	R	8	9	[d]		12	18
CENTRAL AND SOUTH AMERICA								
Columbia:	Bogota	P	NS	1	NS	0	0	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Montigo Bay	P	6	6	0	0	150	101
Venezuela:	Caracas	P	0	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	3	2	0 (4)	1	11 (4)	13
Puerto Rico:	San Juan[c]	P	4	5	0 (5)	0	0 (5)	7
PMN network averages[f]			7	9	0	0	9	11

[a] P, pasteurized milk; R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131:		Cesium-137:	
	Colorado—25 pCi/liter		Colorado—25 pCi/liter
	Michigan—14 pCi/liter		New York—20 pCi/liter
	Oregon—15 pCi liter		Oregon—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [c].

NA, no analysis.

NS, no sample collected.

been omitted from table 3 since levels at the great majority of the stations were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which barium-140 was detected.

Table 4. Barium-140 in milk, March 1969

Sampling location	Radionuclide concentration (pCi/liter)
	Barium-140
Idaho: Idaho Falls (PMN)	1(4)
Mo.: Kansas City (PMN)	1(4)
Nebr.: Omaha	1(4)
Tenn.: Chattanooga	3(5)

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 19 pCi/liter in the United States for the month of March 1969 and the highest 12-month average was 20 pCi/liter (Little Rock, Ark., and Duluth, Minn.) representing 10.0 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 90 pCi/liter in the United States for the month of March 1969 and the highest 12-month average was 111 pCi/liter (Southeast Florida), representing 3.1 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level except Massena, N.Y. (State), 10 pCi/liter, 2 samples.

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Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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FOOD AND DIET SURVEILLANCE

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	January–March 1968	October 1968
Connecticut Diet Study	January–June 1968	November 1968
Tri-City Diet, *HASL*	January–June 1968	April 1969

1. Radionuclides in Institutional Diet Samples
October–December 1968

Bureau of Radiological Health and
Bureau of Community Environmental Management

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Bureau of Community Environmental Management (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions and 8 auxiliary institutions distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1,2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled

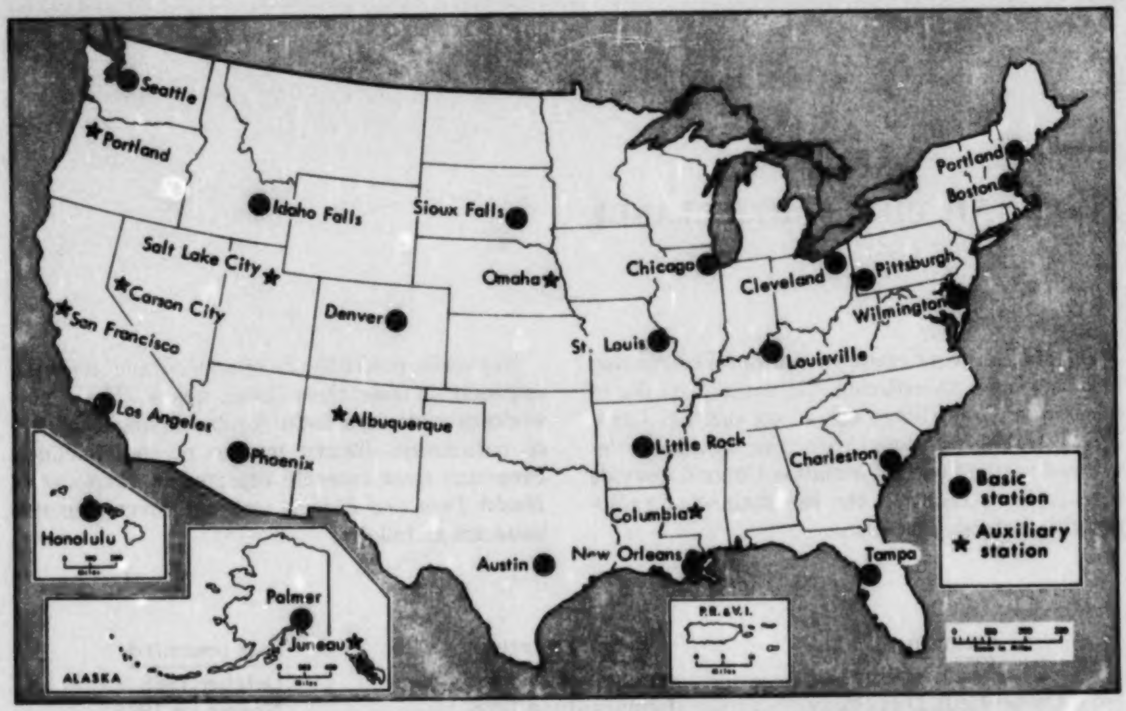
Seattle
Portland
Idaho Falls
Sioux Falls
Salt Lake City
Omaha
Carson City
San Francisco
Denver
Chicago
Cleveland
Pittsburgh
Portland
Boston
Wilmington
St. Louis
Louisville
Los Angeles
Albuquerque
Phoenix
Little Rock
Charleston
Columbia
Honolulu
Austin
New Orleans
Tampa
Palmer
Juneau
ALASKA
P.R. & V.I.
Basic station
Auxiliary station

Figure 1. Institutional diet sampling locations as of October–December 1968

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Table 1. Concentrations and intake of stable elements and radionuclides in institutional total diets of children (9–12 years of age) October–December 1968

Location of institution[a]	Month (1968)	Total weight (kg/day)	Calcium		Potassium		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140		Radium-226	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Palmer	Oct	1.89	0.60	1.13	1.4	2.6	0	0	8	15	0	0	12	25	0	0	0.5	0.9
	Nov	1.21	.77	.93	1.9	2.3	0	0	8	9	0	0	22	27	0	0	.5	1.0
	Dec	1.65	.60	.99	1.4	2.3	0	0	5	9	0	0	24	40	0	0	.3	.5
Ariz: Phoenix	Oct	2.17	.50	1.09	1.4	3.1	0	0	4	10	0	0	0	0	0	0	.6	1.3
	Nov	2.23	.72	1.61	1.2	2.7	0	0	5	10	0	0	0	0	0	0	.4	.9
	Dec	1.90	.46	.87	1.8	3.3	0	0	3	5	0	0	0	0	0	0	.6	1.1
Ark: Little Rock	Oct	1.53	.47	.72	1.3	2.0	NA	NA	5	8	0	0	0	0	0	0	.5	.8
	Nov	1.48	.47	.70	1.4	2.1	NA	NA	9	13	0	0	0	0	0	0	.4	.6
	Dec	1.60	.40	.64	1.3	2.0	NA	NA	5	9	0	0	0	0	0	0	.4	.6
Calif: Los Angeles	Oct[b]	1.84	.40	.74	1.2	2.3	0	0	5	8	0	0	0	0	0	0	.5	.9
	Nov[b]	1.18	.38	.45	1.4	1.6	0	0	0	0	0	0	0	0	0	0	.6	.7
	Dec[b]	1.77	.38	.67	1.3	2.3	0	0	3	5	0	0	0	0	0	0	.4	.7
Colo: Denver	Oct	2.42	.67	1.62	1.3	3.1	0	0	5	11	0	0	12	29	0	0	.5	1.3
	Nov	2.27	.72	1.63	1.6	3.7	0	0	5	12	0	0	16	36	0	0	.5	1.1
	Dec	2.19	.76	1.66	1.7	3.7	0	0	4	9	0	0	11	24	0	0	.4	.9
Del: Wilmington	Oct	2.16	.70	1.51	1.6	3.5	NA	NA	5	11	0	0	13	28	0	0	.8	1.7
	Nov	2.17	.68	1.48	1.6	3.5	NA	NA	8	17	0	0	0	0	0	0	.5	1.1
	Dec	2.18	.64	1.40	1.6	3.5	NA	NA	8	17	0	0	0	0	0	0	.5	1.1
Fla: Tampa	Oct[b]	1.40	.53	.74	1.7	2.3	NA	NA	10	14	0	0	38	53	0	0	.6	.8
	Nov[b]	1.38	.62	.86	1.8	2.5	NA	NA	10	13	0	0	37	51	0	0	.5	.7
	Dec[b]	1.32	.36	.48	1.3	1.7	NA	NA	6	8	0	0	24	32	0	0	.6	.8
Hawaii: Honolulu	Oct	2.38	.48	1.14	1.4	3.3	0	0	2	5	0	0	0	0	0	0	.4	1.0
	Nov	2.37	.40	.95	1.3	3.2	0	0	0	0	0	0	11	26	0	0	.3	.7
	Dec	2.14	.45	.96	1.5	3.2	0	0	3	6	0	0	16	34	0	0	.4	.8
Idaho: Idaho Falls	Oct[b]	1.80	1.37	2.47	1.6	2.9	0	0	9	16	0	0	16	29	0	0	.6	1.1
	Nov[b]	2.11	1.12	2.36	1.8	3.8	0	0	11	23	0	0	25	53	11	23	.5	1.1
	Dec[b]	2.02	1.25	2.53	1.8	3.6	0	0	8	16	14	28	23	46	15	30	.5	1.0
Ky: Louisville	Oct	1.65	.64	1.06	1.6	2.7	NA	NA	9	14	0	0	0	0	0	0	.7	1.2
	Nov	1.58	.68	1.07	1.7	2.7	NA	NA	8	12	0	0	0	0	0	0	.5	.8
	Dec	2.04	.69	1.41	1.6	3.2	NA	NA	12	24	0	0	11	22	0	0	.4	.8
La: New Orleans	Oct	1.76	.49	.86	1.5	2.6	0	0	9	16	0	0	18	32	0	0	.3	.5
	Nov	2.10	.55	1.16	1.6	3.3	0	0	9	18	0	0	12	25	0	0	.5	1.1
	Dec	1.94	.58	1.13	1.5	2.9	0	0	9	18	0	0	15	29	0	0	.4	.8
Maine: Portland	Oct	1.81	.91	1.65	1.7	3.1	NA	NA	11	20	0	0	16	29	19	35	.5	.9
	Nov	1.79	.67	1.20	1.8	3.2	NA	NA	8	14	0	0	20	36	0	0	.6	1.1
	Dec	1.69	.69	1.17	1.7	2.9	NA	NA	9	15	14	24	23	39	0	0	.7	1.2
Mass: Boston	Oct	2.15	.57	1.23	1.3	2.8	0	0	6	13	0	0	16	34	0	0	.3	.6
	Nov	2.30	.55	1.27	1.5	3.5	0	0	7	16	12	28	24	55	14	32	.4	.9
	Dec	2.21	.59	1.30	1.9	4.2	0	0	5	11	0	0	30	66	0	0	.3	.7
Mo: St. Louis	Oct	2.80	1.15	3.22	1.6	4.5	NA	NA	8	22	0	0	18	50	0	0	.8	2.2
	Nov	2.55	.89	2.27	2.0	5.1	NA	NA	7	18	0	0	0	0	0	0	.6	1.5
	Dec[b]	2.58	.91	2.35	1.8	4.6	NA	NA	9	23	0	0	19	49	0	0	.3	.8
Ohio: Cleveland	Oct	1.66	.66	1.10	1.7	2.8	NA	NA	7	12	0	0	0	0	0	0	1.1	1.8
	Nov	1.54	.58	.89	1.7	2.6	NA	NA	6	9	0	0	13	20	0	0	.6	.9
	Dec	1.73	.66	1.14	1.7	2.9	NA	NA	6	10	0	0	18	31	0	0	.6	1.0
Pa: Pittsburgh	Oct	2.34	.54	1.26	1.5	3.5	NA	NA	7	16	0	0	0	0	0	0	.9	2.1
	Nov	2.18	.52	1.13	1.3	2.8	NA	NA	7	15	0	0	12	26	0	0	.8	1.7
	Dec	2.12	.57	1.21	1.5	3.2	NA	NA	10	21	0	0	19	40	0	0	.3	.6
S.C.: Charleston	Oct[b]	1.77	.68	1.20	1.6	2.8	0	0	9	17	0	0	23	41	0	0	.4	.7
	Nov	1.20	.68	.82	1.5	1.8	0	0	11	13	0	0	22	26	0	0	.5	.6
	Dec	1.78	.81	1.44	1.5	2.6	0	0	10	17	0	0	17	30	0	0	.7	1.2
S. Dak: Sioux Falls	Oct[b]	1.67	.64	1.07	1.8	3.0	NA	NA	6	10	0	0	0	0	0	0	.8	1.3
	Nov[b]	1.78	1.12	1.99	1.5	2.7	NA	NA	8	14	12	21	17	30	13	23	2.1	3.7
	Dec[b]	1.48	.68	1.01	1.4	2.1	NA	NA	6	9	0	0	17	25	0	0	.7	1.0
Tex: Austin	Oct	1.68	.45	.76	1.6	2.7	NA	NA	2	4	0	0	0	0	0	0	.2	.3
	Nov	1.95	.80	1.56	1.6	3.1	NA	NA	5	10	0	0	0	0	0	0	.4	.8
	Dec[b]	1.81	.69	1.25	1.2	2.1	NA	NA	5	9	0	0	0	0	0	0	.3	.5
Wash: Seattle	Oct[b]	1.83	.56	1.02	1.8	3.3	0	0	8	14	0	0	20	37	0	0	.4	.7
	Nov[b]	2.06	.59	1.22	1.8	3.6	0	0	6	13	0	0	14	29	0	0	.4	.8
	Dec[b]	1.76	.50	.88	1.8	3.2	0	0	0	0	0	0	0	0	0	0	.5	.9
Institutional average	Oct	2.03	0.63	1.31	1.5	3.0	0	0	6	13	0	0	8	16	1	2	0.6	1.2
	Nov	1.93	0.65	1.24	1.6	3.0	0	0	7	13	1	2	10	19	1	2	0.5	1.0
	Dec	1.94	0.64	1.17	1.6	3.1	0	0	7	13	1	2	15	29	0	0	0.5	0.9

[a] Samples were not collected from the Chicago, Ill. area during this period due to difficulty of finding an appropriate institution.
[b] Since food samples were collected from two or more children who were not between the ages of 9 to 12, data for this month were not used in institutional average.

Table 2. Concentrations and intake of stable elements and radionuclides in institutional total diets of individuals, October–December 1968*

Location of Institution		Month (1968)	Total weight (kg/day)	Calcium		Potassium		Strontium-89		Strontium-90		Cesium-137		Radium-226	
				g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska:	Juneau	Oct	1.26	0.67	0.84	1.5	1.9	0	0	8	10	0	0	0.7	0.9
		Nov	1.24	.68	.84	1.8	2.2	0	0	13	16	14	17	.4	.5
		Dec	.97	.70	.68	1.7	1.6	0	0	11	11	19	18	.5	.5
Calif:	San Francisco	Oct	2.41	.70	1.69	1.6	3.8	0	0	6	15	0	0	.4	1.0
		Nov	1.83	.89	1.63	1.5	2.8	6	11	5	9	11	20	.7	1.3
		Dec	2.48	.62	1.54	1.8	4.4	0	0	3	6	0	0	.3	.7
Miss:	Columbia	Oct	2.15	.76	1.63	1.5	3.2	NA	NA	11	23	16	34	.5	1.1
		Nov	1.87	.85	1.59	1.6	3.0	NA	NA	9	17	0	0	.7	1.3
		Dec	2.35	.98	2.30	1.5	3.5	NA	NA	9	21	14	33	.5	1.2
Nebr:	Omaha	Oct	2.24	1.11	2.49	2.0	4.5	NA	NA	8	18	0	0	1.0	2.2
		Nov	2.27	.96	2.18	1.7	3.9	NA	NA	8	18	14	32	1.2	2.7
		Dec	2.16	.76	1.64	1.8	3.9	NA	NA	6	13	18	39	.3	.6
Nev:	Carson City	Oct	1.83	.75	1.37	1.8	3.3	0	0	4	7	12	22	.5	.9
		Nov	1.31	.79	1.03	1.7	2.2	0	0	5	7	12	16	.6	.8
		Dec	1.43	.77	1.10	2.1	2.9	0	0	2	3	12	17	.6	.9
N. Mex:	Albuquerque	Oct	1.85	.51	.94	1.4	2.6	NA	NA	3	6	0	0	.3	.6
		Nov	2.49	.90	2.24	1.5	3.8	NA	NA	4	11	0	0	.4	1.0
		Dec	2.18	.86	1.87	1.7	3.7	NA	NA	4	8	0	0	.3	.7
Ore:	Portland	Oct	2.24	.63	1.41	1.6	3.5	0	0	8	17	0	0	.7	1.6
		Nov	2.00	.66	1.32	1.9	3.7	0	0	5	11	17	34	.5	1.0
		Dec	2.13	.51	1.09	1.9	4.0	0	0	3	6	0	0	.6	1.3
Utah:	Salt Lake City	Oct	2.08	.50	1.04	1.5	3.1	0	0	4	9	11	23	.5	1.0
		Nov	1.83	.75	1.37	1.2	2.1	0	0	3	5	11	20	.3	.5
		Dec	2.33	.58	1.35	1.6	3.7	0	0	5	10	14	33	.3	.7
Institutional average		Oct	2.01	0.70	1.42	1.6	3.2	0	0	6	13	5	10	0.6	1.2
		Nov	1.88	0.81	1.52	1.6	3.0	1	2	7	12	10	17	0.6	1.1
		Dec	2.00	0.72	1.44	1.7	3.5	0	0	5	10	10	17	0.4	0.8

* Iodine-131 and barium-140 had concentrations below the minimum detectable levels.

periodically. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from October through December 1968, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.93 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1967.

Strontium-90 dietary intake during this period averaged 7 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*4*). Cesium-137 intakes averaged 11 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Barium-140	10 pCi/kg
Cesium-137	10 pCi/kg
Radium-226	0.1 pCi/kg

Data from eight auxiliary stations are included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9–12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1968	October 1968
April–June 1968	January 1969
July–September 1968	April 1969

REFERENCES

(*1*) ANDERSON, E. C., D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(*3*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards. Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961)

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Last presented
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Drinking Water Analysis Program	1961–1966	August 1968
Florida	1965–1966	July 1968
Kansas	July–December 1967	November 1968
Minnesota	January–June 1968	February 1969
New York	January–June 1968	April 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	January–June 1968	April 1969
Washington	July 1967–June 1968	June 1969

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States November-December 1968

Division of Pollution Surveillance
Federal WaterPollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Tables 1 and 2 present the current preliminary results of the alpha and beta radioanalyses for November and December 1968. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figures 1 and 2 indicate the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already

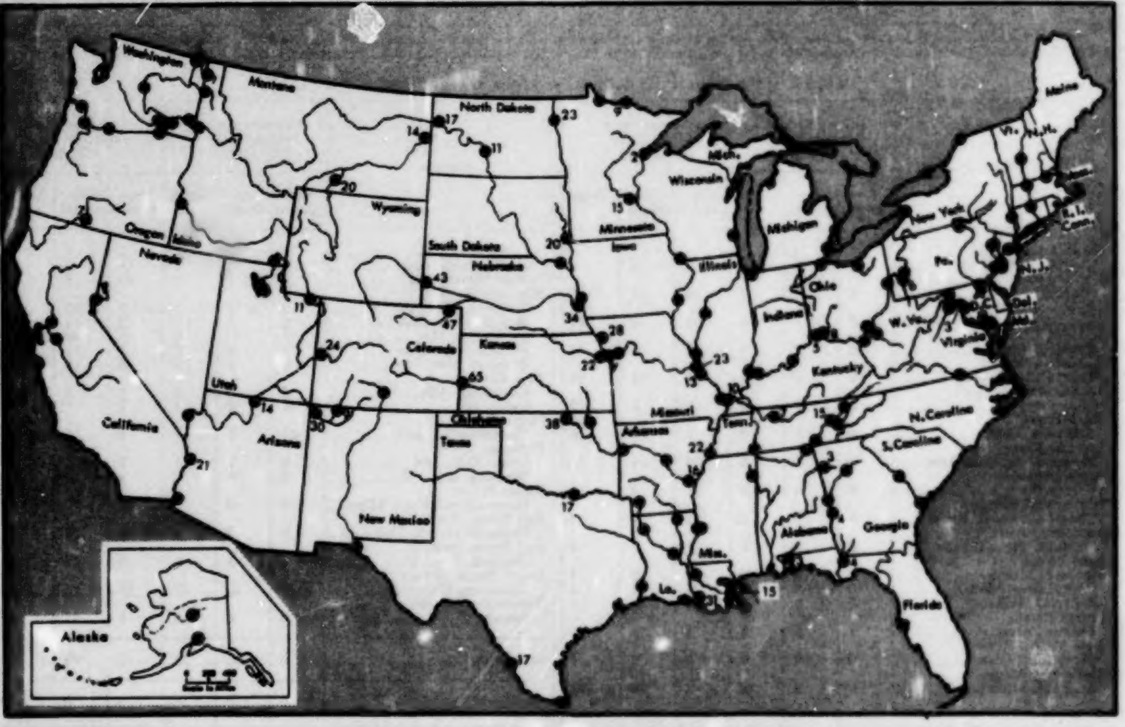
Washington
Montana
North Dakota
17
14
11
23
9
20
Wyoming
South Dakota
Nebraska
Oregon
Idaho
Nevada
43
11
47
Colorado
Kansas
24
65
34
28
22
Utah
14
30
California
Arizona
21
Oklahoma
Texas
38
17
New Mexico
17
Alaska
Minnesota
Iowa
Wisconsin
Mich.
Michigan
Illinois
15
20
23
13
10
Missouri
Arkansas
22
16
Tenn.
Miss.
La.
15
Indiana
Ohio
Kentucky
W. Va.
Virginia
Pa.
New York
Vt.
N.H.
Maine
Mass.
R.I.
Conn.
N.J.
Del.
Md.
D.C.
N. Carolina
S. Carolina
Georgia
Alabama
Florida
3
5
15
3
4

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, November 1968

Table 1. Radioactivity in raw surface waters, November 1968

Station	Average alpha radioactivity (pCi/liter) Suspended	Average alpha radioactivity (pCi/liter) Dissolved	Average alpha radioactivity (pCi/liter) Total	Average beta radioactivity (pCi/liter) Suspended	Average beta radioactivity (pCi/liter) Dissolved	Average beta radioactivity (pCi/liter) Total
Animas River:						
Cedar Hill, N. Mex.	0	2	2	1	8	9
Apalachicola River:						
Chattahoochee, Fla.	0	0	0	1	3	4
Arkansas River:						
Coolidge, Kans.	2	33	35	11	54	65
Ponca City, Okla.	2	3	5	20	18	38
Pendleton Ferry, Ark.	1	0	1	5	11	16
Atchafalaya River:						
Morgan City, La.	4	1	5	21	10	31
Big Horn River:						
Hardin, Mont.	0	7	7	2	18	20
Big Sioux River:						
Sioux Falls, S. Dak.	<1	3	3	1	19	20
Chattahoochee River:						
Columbus, Ga.	0	0	0	1	3	4
Clinch River:						
Kingston, Tenn.*	0	0	0	3	12	15
Colorado River:						
Loma, Colo.	1	8	9	6	18	24
Page, Ariz.	0	5	5	<1	16	16
Parker Dam, Calif-Ariz.	0	3	3	1	20	21
Coosa River:						
Rome, Ga.	0	<1	<1	1	2	3
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	2	5	7
Escambia River:						
Century, Fla.	0	0	0	0	3	3
Great Lakes:						
Duluth, Minn.	0	0	0	0	2	2
Green River:						
Dutch John, Utah	0	2	2	0	11	11
Kansas River:						
DeSoto, Kans.	1	1	2	5	17	22
Klamath River:						
Keno, Ore.	0	1	1	1	6	7
Little Miami River:						
Cincinnati, Ohio	0	0	0	0	8	8
Mississippi River:						
St. Paul, Minn.	0	3	3	1	14	15
E. St. Louis, Ill.	2	2	4	10	3	13
W. Memphis, Ark.	1	1	2	9	13	22
New Orleans, La.	1	1	2	2	13	15
Missouri River:						
Williston, N. Dak.	1	3	4	3	14	17
Bismarck, N. Dak.	0	4	4	1	10	11
St. Joseph, Mo.	2	3	5	10	18	28
Missouri City, Mo.	3	5	8	9	14	23
Monongahela River:						
Pittsburgh, Pa.	0	0	0	0	6	6
North Platte River:						
Henry, Nebr.	0	28	28	3	40	43
Ohio River:						
Cincinnati, Ohio	0	1	1	0	5	5
Cairo, Ill.	1	0	1	2	8	10
Platte River:						
Plattsmouth, Nebr.	4	6	10	8	26	34
Potomac River:						
Washington, D. C	0	0	0	0	3	3
Rainy River:						
International Falls, Minn.	0	0	0	1	8	9
Red River, North:						
Grand Forks, N. Dak.	0	2	2	2	21	23
Red River, South:						
Denison, Tex.	0	0	0	0	17	17
Rio Grande:						
Laredo, Tex.	2	4	6	6	11	17
San Juan River:						
Shiprock, N. Mex.	11	2	13	19	11	30
South Platte River:						
Julesburg, Colo.	1	29	30	10	37	47
Yellowstone River:						
Sidney, Mont.	1	3	4	5	9	14
Maximum	11	33	35	21	54	65
Minimum	0	0	0	0	2	2

a Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Table 2. Radioactivity in raw surface waters, December 1968

Station	Average alpha radioactivity (pCi/liter) Suspended	Average alpha radioactivity (pCi/liter) Dissolved	Average alpha radioactivity (pCi/liter) Total	Average beta radioactivity (pCi/liter) Suspended	Average beta radioactivity (pCi/liter) Dissolved	Average beta radioactivity (pCi/liter) Total
Apalachicola River:						
Chattahoochee, Fla.	1	0	1	2	2	4
Arkansas River:						
Ponca City, Okla.	4	3	7	18	17	35
Atchafalaya River:						
Morgan City, La.	5	1	6	14	8	22
Big Horn River:						
Hardin, Mont.	0	3	3	5	17	22
Big Sioux River:						
Sioux Falls, S. Dak.	0	4	4	2	17	19
Chattahoochee River:						
Columbus, Ga.	0	0	0	2	3	5
Clinch River:						
Kingston, Tenn.*	0	0	0	1	17	18
Colorado River:						
Parker Dam, Calif-Ariz.	0	5	5	0	15	15
Connecticut River:						
Wilder, Vt.	0	0	0	1	3	4
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	1	4	5
Escambia River:						
Century, Fla.	0	0	0	2	2	4
Great Lakes:						
Duluth, Minn.	0	0	0	2	0	2
Port Huron, Mich.	0	0	0	1	4	5
Detroit, Mich.	0	0	0	1	4	5
Kansas River:						
DeSoto, Kans.	1	2	3	4	15	19
Little Miami River:						
Cincinnati, Ohio	0	2	2	0	6	6
Mississippi River:						
St. Paul, Minn.	0	2	2	2	22	24
E. St. Louis, Ill.	2	1	3	6	1	7
W. Memphis, Ark.	4	0	4	11	8	19
New Orleans, La.	4	1	5	13	8	21
Missouri River:						
Williston, N. Dak.	0	1	1	5	19	24
Bismarck, N. Dak.	0	2	2	2	14	16
St. Joseph, Mo.	1	5	6	3	20	23
Kansas City, Kans.	1	4	5	3	11	14
Missouri City, Mo.	2	2	4	7	19	26
Ohio River:						
Cincinnati, Ohio	0	0	0	1	5	6
Cairo, Ill.	1	0	1	7	7	14
Platte River:						
Plattsmouth, Nebr.	<1	7	7	4	25	29
Potomac River:						
Great Falls, Md.	0	1	1	3	5	8
Washington, D. C	0	0	0	1	4	5
Rainy River:						
International Falls, Minn.	0	0	0	0	7	7
Red River, North:						
Grand Forks, N. Dak.	0	0	0	2	22	24
Red River, South:						
Denison, Tex.	0	1	1	0	17	17
South Platte River:						
Julesburg, Colo.	2	35	37	12	73	85
Yellowstone River:						
Sidney, Mont.	0	4	4	3	41	44
Maximum	5	35	37	18	73	85
Minimum	0	0	0	0	0	2

a Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

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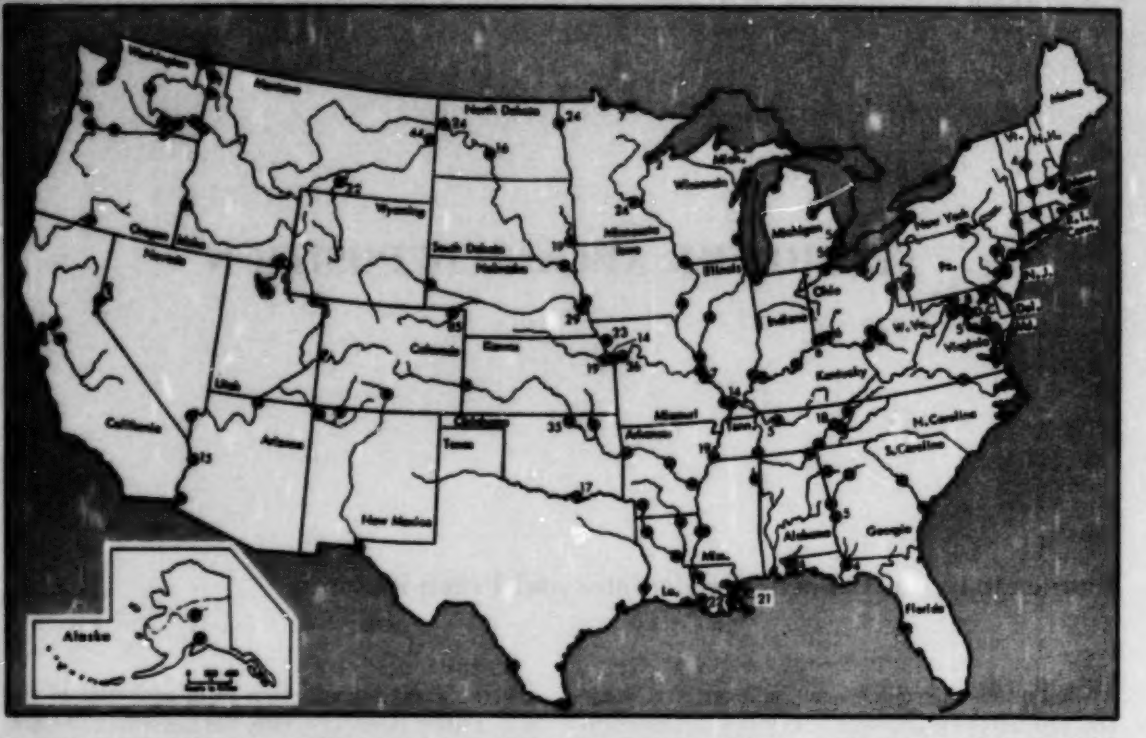
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Montana
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Oregon
Idaho
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Nebraska
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Michigan
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Ohio
New York
Pa.
N.J.
Del.
Md.
W. Va.
Virginia
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
Colorado
Kansas
Utah
California
Arizona
New Mexico
Oklahoma
Texas
Missouri
Arkansas
Tenn.
Kentucky
N. Carolina
S. Carolina
Georgia
Alabama
Miss.
La.
Florida
Alaska
24
44
16
22
24
29
23
14
35
17
21

Figure 2. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, December 1968

provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations in the Water Pollution Surveillance System for 1961 through 1965 has been presented (7). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During November 1968, the following stations showed alpha values in excess of 15 pCi/liter on radioactivity for either suspended or dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During December 1968, the following station showed alpha values in excess of 15 pCi/liter on radioactivity for either suspended or dissolved solids:

South Platte River; Julesburg, Colo.

None of the stations showed a gross beta radioactivity in excess of 150 pCi/liter during November and December 1968.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
(7) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network
March 1969

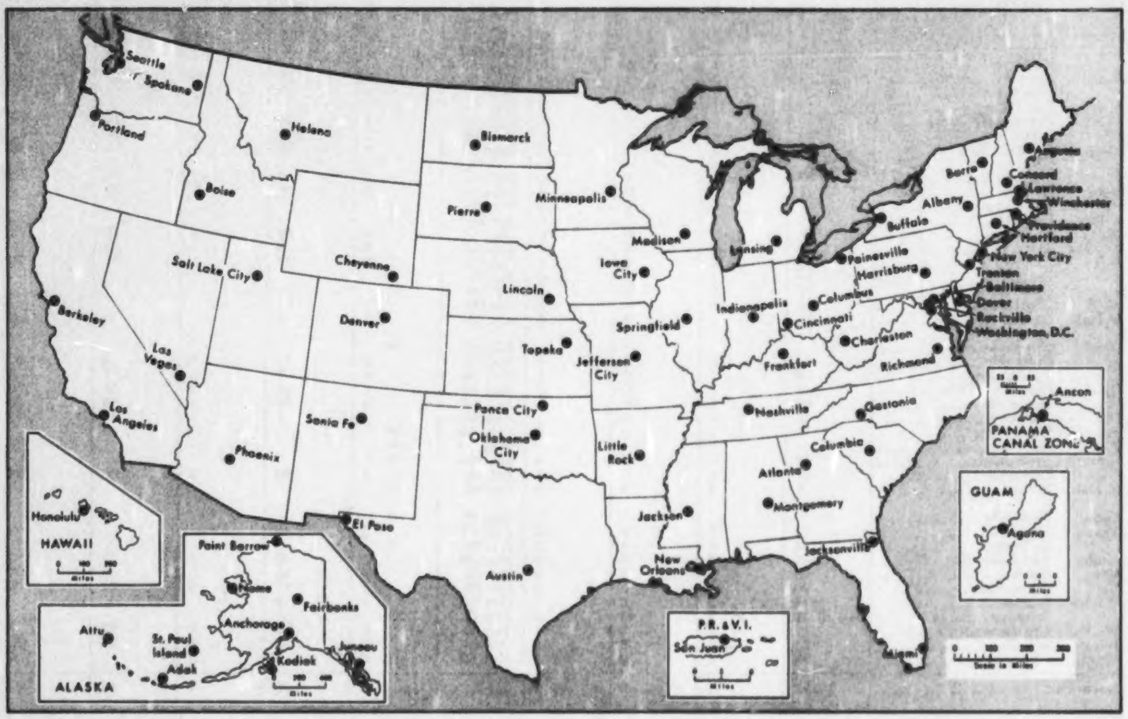
Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during March 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.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Lawrence
Winchester
Albany
Providence
Hartford
Buffalo
Madison
Lansing
Painesville
New York City
Harrisburg
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Salt Lake City
Cheyenne
Iowa City
Lincoln
Berkeley
Denver
Indianapolis
Columbus
Springfield
Cincinnati
Topeka
Jefferson City
Charleston
Frankfort
Richmond
Las Vegas
Ancon
PANAMA CANAL ZONE
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Little Rock
Columbia
Phoenix
Atlanta
GUAM
Agana
Honolulu
HAWAII
Montgomery
Jackson
El Paso
Point Barrow
Nome
Fairbanks
Austin
New Orleans
Jacksonville
Anchorage
Juneau
Attu
St. Paul Island
Adak
Kodiak
ALASKA
P.R. & V.I.
San Juan
Miami
0 100 200 300
Scale in Miles
Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, March 1969

Station location	Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
	Air	Maximum	Minimum	Average [a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala: Montgomery	20	2	0	1	Sept 68	5	134	5	134	0
Alaska: Adak	7	2	1	2	Apr 68	(c)				
Anchorage	6	0	0	0	Oct 68	(c)				
Attu Island	16	0	0	0	Mar 69	(c)				
Fairbanks	(b)				Nov 68	(c)				
Juneau	19	0	0	0	Dec 68	13	222	13	222	0
Kodiak	(b)				Jan 69	(c)				
Nome	(b)				May 69	(c)				
Point Barrow	29	0	0	0	Apr 69	(c)				
St. Paul Island	1	1	1	1	June 69	(c)				
Ariz: Phoenix	21	10	1	5	Dec 68	(c)				
Ark: Little Rock	11	3	0	1	Oct 68	(c)				
Calif: Berkeley	21	1	0	0	Jan 69	5	35	5	35	0
Los Angeles	20	1	0	1	May 69	(c)				
C.Z: Ancon	16	0	0	0	Jan 69	(c)				
Colo: Denver	20	7	0	2	Jan 69	4	33	(d)		
Conn: Hartford	20	0	0	0	Nov 68	4	43	4	43	0
Del: Dover	21	1	0	0	July 69	(c)				
D.C: Washington	9	1	0	0	Apr 69	(c)				
Fla: Jacksonville	21	1	0	0	Oct 68	6	116	6	116	80
Miami	16	1	0	0	Nov 68	4	40	4	40	0
Ga: Atlanta	21	1	1	1	June 69	1	43	1	43	30
Guam: Agana	(b)				July 69	(c)				
Hawaii: Honolulu	30	2	0	0	Mar 69	1	50	(d)		
Idaho: Boise	22	4	0	1	Mar 69	4	11	4	11	0
Ill: Springfield	19	2	0	1	Apr 69	(c)				
Ind: Indianapolis	20	4	0	1	June 69	5	24	5	24	29
Iowa: Iowa City	18	1	0	0	Jan 69	4	29	4	29	0
Kans: Topeka	20	2	0	0	Oct 68	2	25	2	25	2
Ky: Frankfort	12	4	1	1	Apr 69	(c)				
La: New Orleans	20	1	0	0	Apr 69	7	207	(d)		
Maine: Augusta	19	0	0	0	May 69	11	48	11	48	0
Md: Baltimore	19	1	0	0	Nov 68	3	30	3	30	12
Rockville	10	1	0	0	Mar 69	(c)				
Mass: Lawrence	19	0	0	0	July 69	3	45	3	45	23
Winchester	19	0	0	0	Feb 69	5	52	5	52	0
Mich: Lansing	13	4	0	1	Mar 69	(c)				
Minn: Minneapolis	21	0	0	0	July 69	3	24	3	24	9
Miss: Jackson	19	1	0	0	May 69	4	158	4	158	41
Mo: Jefferson City	20	2	0	0	June 69	3	30	3	30	0
Mont: Helena	19	2	0	1	Feb 69	2	2	2	2	3
Nebr: Lincoln	19	1	0	0	June 69	2	25	2	25	8
Nev: Las Vegas	16	2	0	1	Nov 68	(c)				
N.H: Concord	20	0	0	0	Apr 69	(c)				
N.J: Trenton	21	1	0	0	May 69	4	40	4	40	22
N. Mex: Santa Fe	13	2	0	1	Feb 69	3	8	3	8	10
N.Y: Albany	12	2	0	1	June 69	3	34	3	34	78
Buffalo	19	1	0	0	Jan 69	(c)				
New York City	21	0	0	0	Feb 69	(c)				
N.C: Gastonia	16	11	1	3	Jan 69	2	60	(d)		
N.Dak: Bismarck	21	0	0	0	Apr 69	3	3	3	3	0
Ohio: Cincinnati	(b)				July 69	(c)				
Columbus	17	6	0	1	May 69	2	22	0	0	(e)
Painesville	20	1	0	1	Nov 68	6	7	6	7	6
Okla: Oklahoma City	19	1	0	0	Mar 69	2	54	2	54	0
Ponca City	20	2	0	1	Nov 68	3	38	3	38	0
Ore: Portland	18	2	0	1	June 69	3	15	3	15	1
Pa: Harrisburg	13	1	0	0	June 69	(c)				
P.R: San Juan	(b)				May 69	(c)				
R.I: Providence	18	0	0	0	Mar 69	(c)				
S.C: Columbia	17	1	0	0	Feb 69	5	90	5	90	24
S. Dak: Pierre	8	2	0	0	Dec 68	(c)				
Tenn: Nashville	(b)				Mar 69	(c)				
Tex: Austin	20	6	1	2	July 69	5	46	(d)		
El Paso	13	5	1	2	Apr 69	(c)				
Utah: Salt Lake City	31	2	0	1	May 69	5	48	3	7	1
Vt: Barre	18	1	0	0	Oct 68	5	36	5	36	0
Va: Richmond	20	1	0	0	Oct 68	6	72	6	72	32
Wash: Seattle	24	2	0	0	Oct 68	2	18	(d)		
Spokane	21	2	0	0	July 69	(c)				
W. Va: Charleston	17	3	0	1	Feb 69	6	27	6	27	3
Wisc: Madison	21	1	0	0	Oct 68	6	33	6	33	34
Wyo: Cheyenne	20	3	0	1	Nov 68	2	7	2	7	13
Network summary	1,187	11	0	[illegible]		4	50	4	46	13

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

41

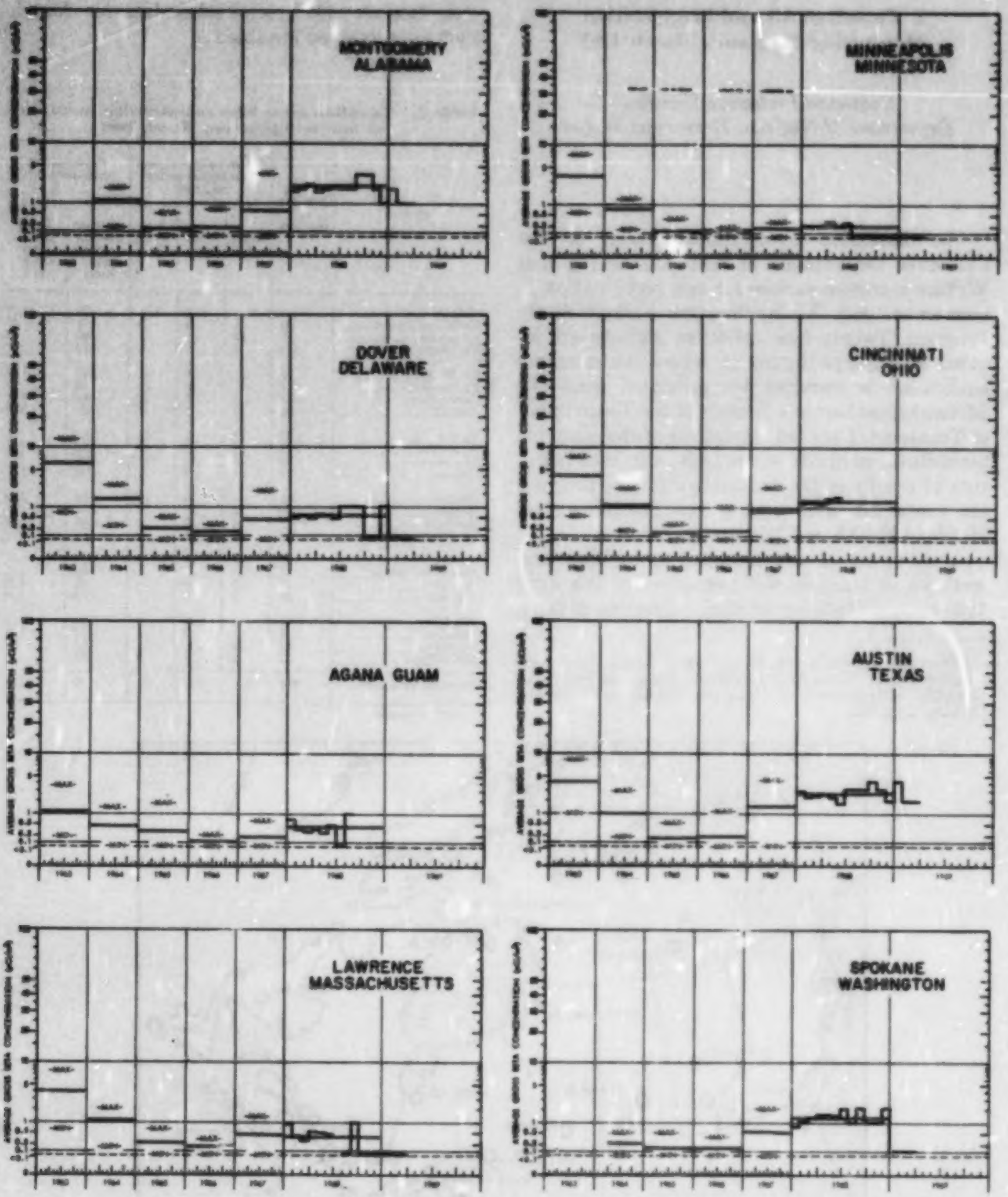

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963-March 1969

2. Canadian Air and Precipitation Monitoring Program[1], March 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the June 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for March 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, March 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	5	0.1	0.1	0.1	30	1.0
Coral Harbour	30	.1	.0	.0	27	.2
Edmonton	31	.2	.1	.1	68	.5
Ft. Churchill	31	.1	.0	.1	36	.2
Ft. William	17	.1	.1	.1	183	1.5
Fredericton	31	.2	.0	.1	16	.7
Goose Bay	31	.1	.0	.1	42	3.1
Halifax	31	.2	.0	.1	50	3.0
Inuvik	31	.1	.0	.1	48	.5
Montreal	31	.1	.0	.1	24	1.1
Moosonee	30	.2	.0	.1	NS	NS
Ottawa	31	.1	.0	.1	20	1.0
Quebec	31	.1	.0	.1	16	1.3
Regina	30	.1	.0	.1	27	.4
Resolute	29	.2	.0	.1	45	.2
St. John's, Nfld	29	.1	.0	.1	15	2.6
Saskatoon	31	.1	.0	.1	42	.3
Saulte Ste Marie	31	.1	.0	.1	29	1.1
Toronto	31	.2	.0	.1	30	1.2
Vancouver	31	.2	.0	.1	28	2.4
Whitehorse	31	.1	.0	.1	28	.3
Windsor	31	.1	.0	.1	27	1.4
Winnipeg	31	.2	.1	.1	32	.3
Yellowknife	31	.1	.1	.1	53	.3
Network summary	697	0.2	0.0	0.1	40	1.1

NS, no sample.

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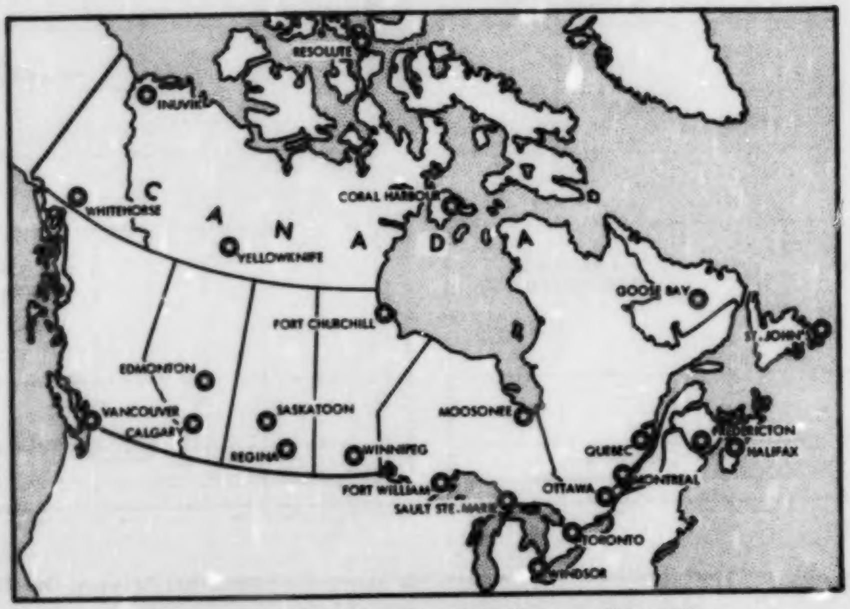
[1] Prepared from information and data in the April 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.


RESOLUTE
INUVIK
C
A
N
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WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
MOOSONEE
FREDERICTON
REGINA
WINNIPEG
QUEBEC
HALIFAX
MONTREAL
FORT WILLIAM
OTTAWA
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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3. Pan American Air Sampling Program March 1969

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. It should be noted that a new sampling station has been established in Quito, Ecuador. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports.* The March 1969 air monitoring results from the participating countries are given in table 3.

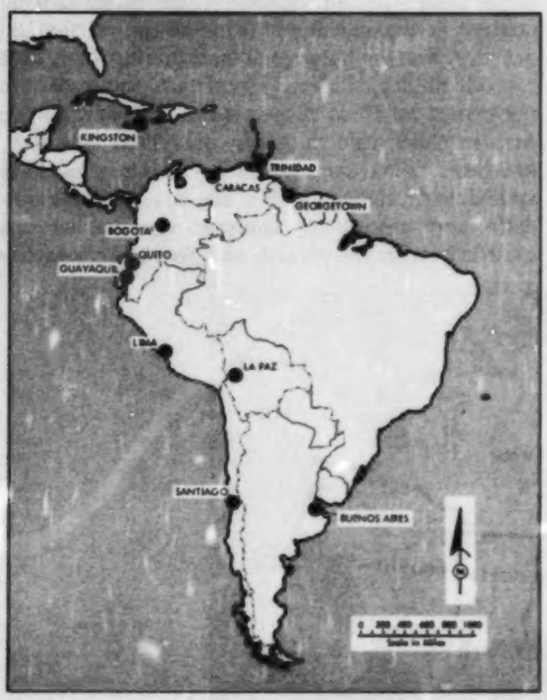

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, March 1969

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average ᵃ
Argentina: Buenos Aires	15	0.30	0.11	0.19
Bolivia: La Paz	3	.02	.01	.01
Chile: Santiago	30	.86	.03	.19
Colombia: Bogota	11	.04	.01	.02
Ecuador: Guayaquil	21	.06	.01	.04
Quito	15	.19	.00	.01
Guyana: Georgetown	18	.10	.00	.03
Jamaica: Kingston	1	.06	.06	.06
Peru: Lima	NS			
Venezuela: Caracas	12	.09	.02	.05
West Indies: Trinidad	20	.25	.03	.09
Pan American summary	140	0.86	0.00	0.06

ᵃ The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no sample.

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(*3*) MAR, P. G. Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The Operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Bone, April-June 1968[1]

Bureau of Radiological Health
U.S. Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium-90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at Northeastern Radiological Health Laboratory of the Bureau of Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium-90) are analyzed periodically and crosscheck analyses are carried out quarterly with the Health and Safety Laboratory

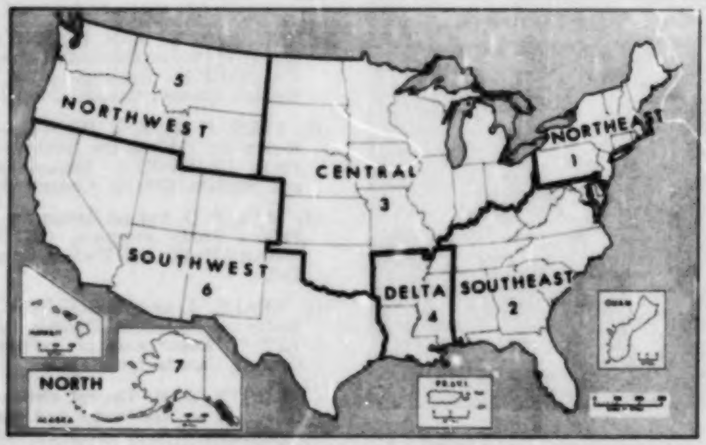

Figure 1. Geographical regions for human bone sampling

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[1] Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, April–June 1968

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:						
N. J.	V	1	M	71.7 ± 11.0[c]	24.1	2.97
N. Y.	V	3	M	91.9 ± 8.9	32.7	2.81
N. Y.	V	3	M	53.4 ± 6.3	19.7	2.71
Pa.	V	8	M	31.4 ± 4.0	19.1	1.64
N. Y.	V	8	F	64.1 ± 6.9	32.8	1.95
Pa.	V	9	M	46.9 ± 8.8	30.1	1.55
Mass.	V	11	M	59.1 ± 7.2	35.6	1.66
N. J.	V	12	M	110.0 ± 8.0	40.0	2.75
Vt.	V	13	M	91.1 ± 7.4	36.8	2.47
Mass.	V	15	M	90.4 ± 7.3	40.8	2.21
Vt.	V	16	M	116.0 ± 12.0	46.7	2.48
	V	18	M	167.0 ± 16.0	54.5	3.06
N. J.	V	19	M	119.0 ± 10.0	58.3	2.04
Mass.	V	20	F	93.3 ± 10.0	34.3	2.72
	V	20	M	173.0 ± 12.0	55.5	3.11
	V	20	M	152.0 ± 12.0	67.7	2.24
Vt.	V	21	M	108.0 ± 9.3	52.5	2.05
N. Y.	V	21	M	115.0 ± 10.0	48.5	2.37
Mass.	V	21	M	175.0 ± 12.0	48.8	3.58
N. Y.	V	23	M	86.0 ± 8.0	42.3	2.03
Mass.	V	23	F	76.3 ± 7.5	46.8	1.63
N. Y.	V	24	F	85.5 ± 12.0	60.7	1.40
	V	25	M	76.2 ± 8.2	52.0	1.46
Southeast:						
S. C.	V	2	F	174.0 ± 12.0	30.7	5.66
Md.	V	3	F	71.9 ± 13.0	28.6	2.51
	V	3	M	79.7 ± 8.9	34.6	2.30
S. C.	V	4	M	97.2 ± 8.8	30.8	3.15
Md.	V	4	M	97.4 ± 9.4	27.4	3.55
S. C.	V	5	F	75.0 ± 7.0	27.3	2.74
Md.	V	5	F	77.2 ± 8.7	28.1	2.74
Ga.	V	9	F	129.0 ± 9.1	32.0	4.03
Md.	V	10	F	108.0 ± 10.0	30.6	3.52
	V	11	F	146.0 ± 12.0	47.3	3.08
	V	11	F	57.8 ± 7.7	31.5	1.83
	V	12	M	94.7 ± 8.8	36.6	2.58
	V	13	F	135.0 ± 13.0	50.5	2.67
S. C.	V	13	M	170.0 ± 12.0	45.8	3.71
Md.	V	13	M	47.0 ± 5.2	40.4	1.16
	V	14	F	263.0 ± 17.0	68.9	3.81
	V	14	M	84.9 ± 10.0	44.2	1.92
	V	14	F	149.0 ± 11.0	56.3	2.65
	V	14	M	114.0 ± 10.0	43.9	2.59
N. C.	V	16	M	69.1 ± 8.0	47.9	1.44
	V	16	F	81.5 ± 8.5	38.8	2.10
Md.	V	16	F	158.0 ± 9.7	42.6	3.70
	V	17	M	115.0 ± 10.0	57.7	1.99
	V	17	M	104.0 ± 11.0	44.1	2.35
	V	17	M	170.0 ± 11.0	58.6	2.90
	V	17	M	202.0 ± 14.0	61.1	3.30
N. C.	V	17	M	151.0 ± 12.0	49.3	3.06
Md.	V	17	M	74.9 ± 6.8	43.0	1.74
N. C.	V	18	M	157.0 ± 14.0	52.2	3.00
S. C.	V	19	M	223.0 ± 13.0	51.2	4.35
Md.	V	19	M	126.0 ± 12.0	49.8	2.53
S. C.	V	20	M	132.0 ± 13.0	61.4	2.14
Md.	V	20	F	103.0 ± 9.2	59.3	1.73
	V	21	M	72.1 ± 6.5	40.5	1.78
	V	21	M	89.8 ± 9.6	55.5	1.61
	V	21	M	198.0 ± 15.0	60.4	3.27
	V	21	M	109.0 ± 9.3	47.3	2.30
Tenn.	V	22	M	112.0 ± 14.0	62.7	1.78
Md.	V	22	M	93.8 ± 11.0	48.5	1.93
	V	22	M	110.0 ± 10.0	65.9	1.66
	V	22	M	143.0 ± 10.0	50.1	2.85
N. C.	V	22	M	84.5 ± 11.0	57.8	1.46
Md.	V	22	M	114.0 ± 11.0	55.6	2.05
	V	23	M	84.9 ± 9.9	47.3	1.79
	V	23	F	91.9 ± 12.0	71.4	1.28
	V	23	M	132.0 ± 13.0	54.2	2.43
	V	23	M	96.6 ± 11.0	49.0	1.97
N. C.	V	23	F	72.8 ± 7.4	41.0	1.77
Md.	V	24	M	94.9 ± 8.1	49.1	1.93
Tenn.	V	24	M	69.3 ± 7.7	52.9	1.31
Md.	V	25	M	119.0 ± 9.7	49.6	2.39
	V	25	M	83.8 ± 8.6	52.2	1.60
S. C.	V	25	M	127.0 ± 11.0	61.4	2.06
	V	25	M	104.0 ± 9.9	44.1	2.35
Central:						
Wis.	V	1	F	69.7 ± 7.9	25.2	2.76
Ind.	V	2	F	67.9 ± 8.5	29.6	2.29
Wis.	V	3	M	143.0 ± 11.0	35.9	3.98
Ohio	V	4	F	65.8 ± 7.8	26.6	2.47
Wis.	V	4	M	125.0 ± 11.0	50.8	2.46
Minn.	V	4	M	129.0 ± 9.8	24.6	5.24
Wis.	V	4	F	101.8 ± 8.7	24.7	4.12
	V	6	F	76.9 ± 10.0	33.3	2.30
	V	7	M	96.0 ± 8.9	33.4	2.87

See footnotes at end of table.

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Table 1. Strontium-90 in human bone, April–June 1968—Continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Central:						
Minn.	V	8	F	68.0 ± 6.8	27.7	2.46
Ohio	V	11	M	119.0 ± 8.2	32.4	3.67
	V	11	M	120.0 ± 17.0	67.8	1.80
Mich.	V	12	F	102.0 ± 11.0	42.3	2.41
Ohio	V	12	M	113.0 ± 10.0	56.5	2.00
	V	12	F	118.0 ± 13.0	56.2	2.09
	V	13	M	132.0 ± 13.0	64.7	2.03
Ill.	V	13	M	83.2 ± 7.9	38.8	2.14
Ohio	V	16	M	134.0 ± 9.6	54.2	2.47
	V	16	F	130.0 ± 12.0	61.0	2.24
	V	17	M	214.0 ± 17.0	71.5	2.99
Minn.	V	17	M	112.0 ± 11.0	51.0	2.19
Mich.	V	18	F	244.0 ± 19.0	62.1	3.93
Ohio	V	18	M	160.0 ± 12.0	68.8	2.33
Mich.	V	19	F	202.0 ± 12.0	50.0	4.04
	V	20	M	145.0 ± 14.0	44.4	3.26
Ohio	V	20	F	113.0 ± 14.0	59.1	1.91
	V	20	M	113.0 ± 12.0	55.4	2.03
Wis.	V	22	M	94.8 ± 8.7	44.5	2.13
Ohio	V	24	M	44.7 ± 5.4	29.3	1.52
	V	24	F	71.3 ± 9.9	58.9	1.21
Northwest:						
Ore.	V, SK	0	M	99.2 ± 8.1	37.5	2.64
	V	10	M	50.0 ± 6.5	37.8	1.32
	V	14	M	51.4 ± 5.9	34.4	1.49
	V	16	M	125.0 ± 13.0	53.2	2.34
	V	17	M	158.0 ± 12.0	47.3	3.34
	V	18	M	114.0 ± 12.0	52.5	2.17
	V	20	M	93.3 ± 12.0	60.3	1.54
	V	21	F	72.5 ± 10.0	48.9	1.48
Ohio	V	25	M	61.2 ± 7.0	48.7	1.25
Southwest:						
Tex.	V	0	F	325.0 ± 22.0	32.3	10.06
Colo.	V	10	F	111.0 ± 11.0	48.6	2.28
	V	12	M	80.6 ± 7.0	33.0	2.44
	V	16	M	133.0 ± 13.0	47.0	2.83
	V	16	F	90.8 ± 9.3	48.6	1.86
	V	17	M	99.4 ± 10.0	49.8	1.99
	V	17	M	70.6 ± 8.5	44.6	1.58
	V	17	M	83.5 ± 9.5	51.7	1.61
	V	17	M	114.0 ± 11.0	54.9	2.07
	V	17	M	118.0 ± 9.8	47.7	2.47
	V	18	M	127.0 ± 10.0	47.3	2.68
	V	18	M	149.0 ± 15.0	56.0	2.66
	V	19	F	99.1 ± 9.7	53.9	1.83
	V	19	M	77.2 ± 8.9	40.5	1.90
	V	20	M	53.0 ± 9.5	51.1	1.03
	V	20	M	90.4 ± 8.6	54.6	1.65
	V	21	M	97.4 ± 8.5	51.2	1.90
	V	21	M	107.0 ± 10.0	55.3	1.93
Calif.	V	21	M	71.2 ± 7.4	49.7	1.43
Colo.	V	24	M	57.6 ± 6.5	44.6	1.29
North:						
Alaska	R	13	F	476.0 ± 50.0	116.0	4.10

[a] Type of bone: vertebrae, V; rib, R; skull, SK.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

of the AEC, which performs similar analyses.

The analytical results for strontium-90 in individual bones from persons dying during the second quarter (April–June) of 1968 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

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Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1967	February 1969
January–March 1968	April 1969

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Atomics International, and the Paducah Plant.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Atomics International[2]
July–December 1968

North American Rockwell Corporation
Canoga Park, California

Atomics International, a division of North American Rockwell Corporation, has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, California, approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 1.

The basic concept of radiological hazard control at Atomics International encourages total containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check

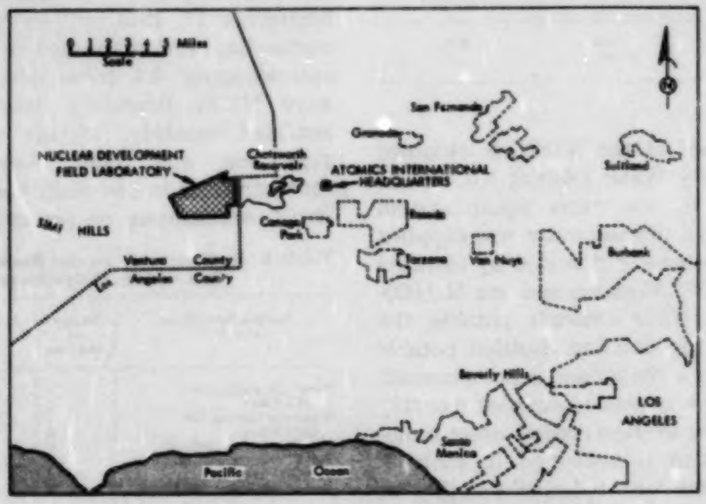
0 1 2 3 4 5 Miles
Scale
NUCLEAR DEVELOPMENT FIELD LABORATORY
Chatsworth Reservoir
ATOMICS INTERNATIONAL HEADQUARTERS
San Fernando
Granada
Sunland
SIMI HILLS
Canoga Park
Reseda
Tarzana
Van Nuys
Burbank
Ventura County
Los Angeles County
Beverly Hills
LOS ANGELES
Santa Monica
Pacific Ocean

Figure 1. Atomics International facilities and vicinity

on the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design.

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[2] Summarized from "Environmental Monitoring, Semiannual Report, July 1 to December 31, 1968" Atomics International, Division of North American Rockwell Corporation.

The environs of Atomics International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. In addition, continuous environmental air monitoring at the sites provides information concerning airborne particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV-70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20-cubic meters. The average concentration of long-lived beta-gamma radioactivity on airborne particulates is presented in table 1 for July–December 1968.

Table 1. Beta-gamma radioactivity of airborne particulates, Atomics Intl., July–December 1968

Location	July–December 1968	
	Number of samples	Average concentration (pCi/m^3)
Headquarters	349	0.18
NDFL	1,095	.17

Water monitoring

Process water used at the NDFL is obtained from Ventura County Water District No. 10 and distributed onsite by the same piping system previously used when process water was supplied by onsite wells. Pressure is provided by elevated storage tanks, one 50,000-gallon and one 500,000-gallon tank onsite. While clinically potable, the water is not used for drinking. Bottled potable water is delivered by a vendor and is not analyzed. Water from the pipe system is sampled monthly at two locations. The average process water radioactivity concentration is presented in table 2.

Table 2. Well water radioactivity, NDFL site July–December 1968

Type of radioactivity	July–December 1968	
	Number of samples	Average concentration (pCi/m^3)
Alpha	13	0.14
Beta-gamma	12	5.1

Water samples are also collected monthly at Chatsworth Reservoir which is operated by the Los Angeles City Department of Water and Power. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir water supply inlet located on the north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 3.

Table 3. Chatsworth Reservoir water radioactivity Atomics Intl., July–December 1968

Sample	Type of radioactivity	July–December 1968	
		Number of samples	Average concentration (pCi/liter)
Lake surface	Alpha	6	0.22
	Beta-gamma	6	6.2
Supply surface	Alpha	6	.30
	Beta-gamma	6	4.9

Surface discharged waters from NDFL facilities drain into holding reservoirs on adjacent property. When full, the main reservoir is drained into Bell Creek, a tributary of the Los Angeles River in the San Fernando Valley, Los Angeles County. Pursuant to the requirements of Los Angeles Regional Water Quality Control Board Resolution 66–49 of September 21, 1966, an environmental sampling station has been established in Bell Creek Canyon approximately 3.4 miles downstream from the south NDFL Boundary. Samples, obtained and analyzed monthly, include stream bed mud, vegetation, and water. Average radioactivity concentrations in the main holding reservoir and Bell Creek samples are presented in table 4.

Table 4. Radioactivity in the Rocketdyne reservoir and Bell Creek[a], July–December 1968

Sample description (units)	Number of samples	Alpha radioactivity	Beta radioactivity
Reservoir station 6[a] (pCi/liter)	5	0.19	9.3
Reservoir station 12[a] (pCi/liter)	6	.08	7.1
Bell Creek mud (pCi/g)	6	.33	25
Bell Creek vegetation (pCi/g ash)	6	.42	169
Bell Creek water (pCi/liter)	3	.03	5.2

[a] Location not shown on on figure 1.

Soil and vegetation monitoring

Soil and vegetation are regularly sampled at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Radioactivity in soil samples is presented in table 5.

Table 5. Radioactivity in the soil, Atomics Intl. July–December 1968

Area	Type of radioactivity	July–December 1968	
		Number of samples	Average concentration (pCi/g)
Onsite	Alpha	72	0.46
	Beta-gamma	72	27
Offsite	Alpha	24	.47
	Beta-gamma	24	26

Vegetation samples obtained in the field are of the same plant type wherever possible, generally, sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area. Vegetation leaves are stripped from plants and transferred to the laboratory for analysis. Plant root systems are not routinely sampled. Radioactivity in vegetation samples is presented in table 6.

Table 6. Radioactivity in vegetation, Atomics Intl. July–December 1968

Area	Type of radioactivity	July–December 1968	
		Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	72	0.47
	Beta-gamma	72	120
Offsite	Alpha	24	.46
	Beta-gamma	24	138

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1967	June 1968
January–June 1968	December 1968

2. Paducah Plant[3]
July–December 1968

Union Carbide Corporation
Paducah, Kentucky

The Paducah Plant is a government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. The uranium hexafluoride manufacturing plant, a former source of diffusion plant feed, was placed on standby in June of 1964 and was reactivated in August 1968. Parts of the associated uranium metal foundry, usually on standby, are operated infrequently as the need arises. A decontamination and uranium recovery facility operates to prepare equipment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, ballasts, or other shapes on a nonroutine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium-234, and protactinium-234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Because of the necessity for health protection in process areas, the high intrinsic value of uranium, and the desire to maintain a wholesome relationship with neighboring communities and individuals, the Paducah Plant provides confinement and recovery systems at the plant. The environmental monitoring program provides for continuously sampling the air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this

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[3] Summarized from "Environmental Concentrations of Radioactive Materials Near the Paducah Plant—Report for the Second Half of 1968."

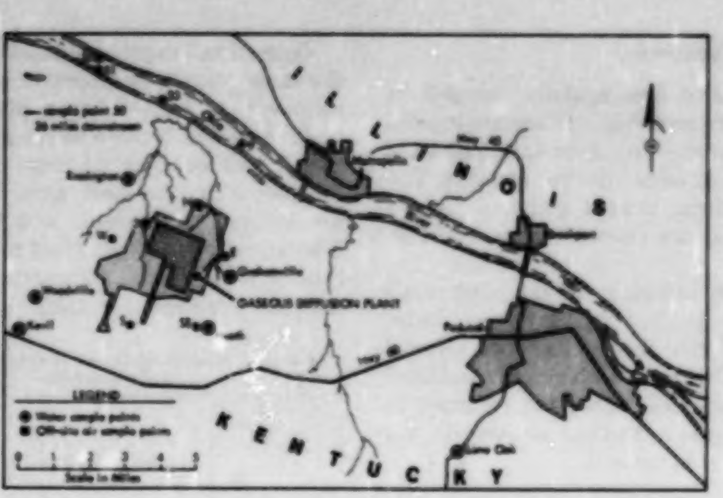

Figure 2. Sampling locations, Paducah Gaseous Diffusion Plant

fence (figure 2). Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The radiation protection standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for offsite exposure of the general population, are those contained in Appendix 0524 of the AEC manual.

The standards specify that the radiation or radioactive materials outside a controlled area, and which have resulted from operations within that controlled area, shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-third of this dose. To meet this standard, the average concentration of radioactivity in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 7 through 10.

Air samples were collected continuously at each of the four stations at the plant perimeter fence and at five stations about 1 mile outside the plant. Air is filtered at 0.3 cfm through 2-inch

Table 7. Uranium concentrations in outdoor air samples, Paducah Plant, July–December 1968

Sample location[a]	Number of samples	Uranium alpha radioactivity[b] (pCi/m³)		
		Maximum	Minimum[c]	Mean[d]
At plant perimeter fence:				
North	27	0.24	<0.02	0.08
East	27	.13	< .02	.04
South	27	.06	< .02	.01
West	27	.05	< .02	.01
Total	108	0.24	<0.02	0.03
About 1 mile outside plant perimeter fence:				
North	27	.06	< .02	.01
East	27	.06	< .02	.01
South	27	.09	< .02	.01
West	27	.06	< .02	.01
Southeast	27	.06	< .02	.01
Total	135	0.09	<0.02	0.01

[a] See figure 2.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 × 10⁴ alpha dis/sec.

[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³.

[d] The AEC standard for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m³.

Table 8. Beta radioactivity in outdoor air samples, Paducah Plant, July–December 1968

Sample location[a]	Number of samples	Beta radioactivity (pCi/m³)		
		Maximum	Minimum[b]	Mean[c]
At plant perimeter fence:				
North	27	3.9	<0.01	1.7
East	27	6.3	< .01	1.2
South	27	.4	< .01	.1
West	27	.5	< .01	.2
Total	108	6.3	<0.01	0.8
About 1 mile outside plant perimeter fence:				
North	27	.68	< .01	.19
East	27	.26	< .01	.15
South	27	.40	< .01	.14
West	27	.31	< .01	.13
Southeast	27	.41	< .01	.15
Total	135	0.68	<0.01	0.15

[a] See figure 2.

[b] The minimum detectable amount of beta-particle emitters in air is 0.1 pCi/m³.

[c] The AEC standard, applicable to this table is 1 × 10^3 pCi/m³, which is the concentration limit of thorium–234, the daughter product of uranium–238. Insignificant amounts of other daughters are present in freshly refined uranium.

diameter membrane filters which are replaced weekly and counted for alpha and beta radioactivity.

The average alpha-particle count—interpreted as uranium, the most likely source of radioactivity—of the 108 and the 135 air samples collected during the second half of 1968 at the perimeter fence and 1 mile, respectively, were 1.5 percent and 0.5 percent of the AEC standard set for individuals residing in the vicinity of a controlled area. The average beta-particle count of these samples was 0.08 percent of the standard at the perimeter fence and 0.02 percent of the standard at 1 mile.

Table 9. Concentrations of uranium in water Paducah Plant, July–December 1968

Sample location[a]	Number of samples	Uranium[b] (pCi/liter)		
		Maximum	Minimum[c]	Mean[d]
Big Bayou Creek 3	27	9	<1	4
Ohio River 9	6	<1	<1	<1
Composite of 50, 51, 52, and 53	6	<1	<1	<1

[a] See figure 2.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 × 10^4 alpha dis/sec.

[c] The minimum detectable uranium in water is 1 pCi/liter.

[d] The AEC standard for natural uranium in water beyond a controlled area is 2 × 10^4 pCi/liter.

Table 10. Concentration of beta-particle emitters in water, Paducah Plant, July–December 1968

Sample location[a]	Number of samples	Beta-particle emitters (pCi/liter)		
		Maximum	Minimum[b]	Mean[c]
Big Bayou Creek 3	27	300	<100	<100
Ohio River 9	6	100	<100	100
Composite of 50, 51, 52, and 53	6	100	<100	<100

[a] See figure 2.

[b] The minimum detectable amount of beta-particle emitters in water is 100 pCi/liter.

[c] The AEC standard for the immediate daughter products of uranium in water released to the environs is 2 × 10^4 pCi/liter.

The average uranium analyses of weekly water samples collected continuously from the Big Bayou Creek during July–December 1968 was 0.02 percent of the AEC standard for water beyond a controlled area. The results of the uranium analyses for each of the 12 grab samples collected at monthly intervals from the Ohio River below the plant were less than 0.01 percent of the AEC standard.

The concentration of beta-particle emitters in the Big Bayou Creek averaged less than 0.5 percent of the AEC standard for the decay products of uranium–238. The beta radioactivity of the Ohio River was less than 0.5 percent of the standard for uranium–238 decay products.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/hr at all sampling stations for July–December 1968.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1967	May 1968
January–June 1968	December 1968

Reported Nuclear Detonations, June 1969

The U.S. Atomic Energy Commission announced a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground by the Atomic Energy Commission at is Nevada Test Site on June 12, 1969.

Errata

In the article "Radioactivity in North Carolina Surface, Ground, and Cistern Waters, January–December 1967" which appeared in the May 1969 issue of *Radiological Health Data and Reports*, the last sentence in the first column of page 214 should read: "If gross beta radioactivity above 5 pCi/liter is detected in a ground water sample, it is analyzed by gamma-ray spectroscopy *and* for radium."

In the Mound Laboratory article on page 233 of the May 1969 issue of *Radiological Health Data and Reports* there is an error in the units of tables 7 and 8. The columns titled "concentration" in table 7 should have units of "fCi/m^3." The same column in table 8 should have units of "nCi/m^3."

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

STUDIES OF CHEMICAL AND RADIOCHEMICAL COMPOSITION OF NATURAL GAS FROM THE CAVITY PRODUCED BY THE PROJECT GASBUGGY NUCLEAR SHOT. *C. F. Smith* and *F. F. Momyer. Radiological Health Data and Reports, Vol. 10, July 1969*, pp. 281–288.

Data relating to the chemical and radiochemical results from Project Gasbuggy chimney-gas samples obtained prior to 210 days after detonation (December 10, 1967) are presented for significant nonradioactive components of the gas and for tritium and krypton-85. A discussion of changes in composition occurring during the flaring of 5×10^7 ft^3 gas in the late spring of 1968 is included. Some interpretation of the observed changes is advanced but with the data now available, no definitive conclusions seem warranted. This is a status report of the continuing effort to define and understand the chemical and radiochemical aspects of Project Gasbuggy.

Keywords: Chemical, chimney-gas, Gasbuggy Project, tritium, krypton-85, natural gas.

RADIOECOLOGICAL SURVEILLANCE OF THE WATERWAYS AROUND A NUCLEAR FUELS REPROCESSING PLANT. *N. I. Sax, P. C. Lemon, A. H. Benton*, and *J. J. Gabay. Radiological Health Data and Reports, Vol. 10, July 1969*, pp. 289–296.

A 3-year study of the aquatic ecosystem around a nuclear fuels reprocessing plant, located in western New York State, has been conducted to find and evaluate natural indicators of environmental contamination. The study covered preoperational and early post-operational phases. The ecological vectors selected for study were algae, silt, and fish, all from Cattaraugus Creek and its tributaries. Samples were collected at several points upstream and downstream from the plant effluent and quantitatively analyzed by gamma-ray spectrometry. All vectors analyzed indicated process of uptake and concentration of ruthenium-rhodium-106, cesium-137, cesium-134, and/or zirconium-niobium-95, and sometimes cobalt-60.

In addition, the concept of using natural indicators not native to the streams under study was tested by translocating fresh water clams from Chautauqua Lake, 60-miles southwest of the site, and placing them in the streams around the plant. The clams not only thrived in their new environment but upon analysis showed definite interaction by concentration of the above radioisotopes with the shells showing approximately twice the radioactivity of the soft parts of the clams. This concept might prove to be a sensitive indicator of environmental contamination.

KEYWORDS: Algae, clams, fish, gamma-ray emitters, nuclear fuels reprocessing plant, radionuclides, silt, surveillance, water.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 8, August 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

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Reports

Environmental Surveillance Around A Nuclear Fuel Reprocessing Installation, 1965-1967

William J. Kelleher[1]

A summary report of environmental surveillance around a nuclear fuel reprocessing plant is presented. This report includes data obtained before and after the plant began operations in April 1966. Media monitored included air and milk supplies in the surrounding area; liquid wastes; local watersheds and streams; silt, deer, and fish in the plant perimeter area. Data obtained through 1967 indicate that the discharges from the plant stack have not produced environmental effects from particulate beta-particle emitters or iodine-131 that might constitute a public health hazard. Surveillance of the streams showed greater concentrations of strontium-90 during the fall and winter of 1966–1967 than in the latter part of 1967. Silt removed more cesium-137 than strontium-90; most of the latter was in the dissolved state. The ratio of cesium-137 to cesium-134 (cesium-134 is indicative of spent fuel) in the wastes was about 4 or 5 to 1. The levels of radioactivity in deer and fish were sufficiently high to require careful evaluation of the public health significance.

Spent fuel from nuclear reactors is processed by Nuclear Fuel Services, Inc. (NFS) on a 3,300 acre State-owned site, 30 miles southeast of Buffalo, in the town of Ashford, Cattaraugus County, New York. The company operates under a license from the Atomic Energy Commission (AEC) and is allowed to discharge radioactive materials to the atmosphere and to local water courses. The 3-year surveillance program (1965–1967) includes data obtained before and after the plant started to reprocess fuel elements in April 1966.

The location of the site and its relation to Cattaraugus and Buttermilk Creeks is shown in figure 1. Atmospheric discharges from the plant are through a 200-foot-high stack at an air-flow rate of 40,000 to 45,000 cfm. Permitted discharges are: krypton-85, 12,600 curies per day; iodine-131, 3.3 curies per year; gross alpha and gross beta

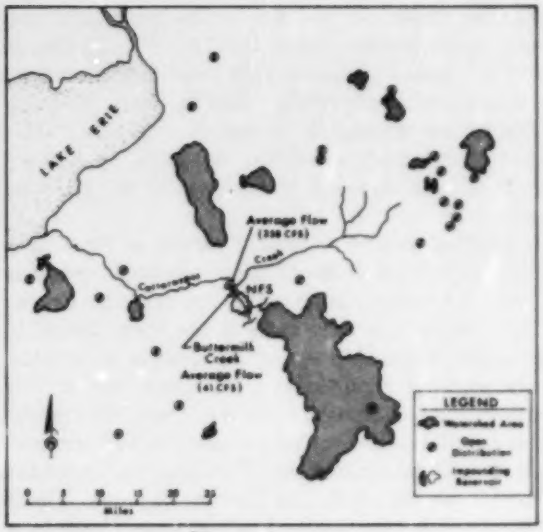

Figure 1. Nuclear Fuel Services environs; open reservoirs, impounding reservoirs, and watersheds of public water systems

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[1] William J. Kelleher, P. E., is chief, Nuclear Engineering and Surveillance Section, Bureau of Radiological Health, New York State Department of Health, Albany, N.Y.

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radioactivity on particulates, 0.1 microcuries per second (*1*).

The liquid wastes are continuously monitored while passing into one of two intercepting tanks. After laboratory analysis, the tank content is drained into the first of three holding lagoons or is pumped back to the plant for evaporation and storage. The holding lagoons are in series and provide 40 to 120 days of storage depending on liquid-waste flow. The third lagoon is routinely analyzed and discharges are made at a rate such that concentrations after dilution in Cattaraugus Creek averaged for the year will not exceed the concentrations set forth in the Code of Federal Regulations 10-CFR-20[a] for releases to unrestricted areas, and at any time shall not exceed twice these concentrations (*1*). Each day, the flow in Cattaraugus Creek is determined and the release rate from lagoon 3 (controlled by a V-notch weir) is regulated.

Discharge of the waste is to Franks Creek, which flows into Erdman Brook, to Buttermilk Creek, to Cattaraugus Creek, and thence to Lake Erie. The State-owned site includes a small section of Cattaraugus Creek on both shores where Buttermilk Creek enters Cattaraugus Creek. Although the waste is diluted as it flows into the different streams, there are approximately 2 miles of Buttermilk Creek and 1 mile of Erdman Brook and Franks Creek on the site where concentrations are much greater than the 10-CFR 20-limits.

The waste lagoons and the contaminated sections of Buttermilk, Franks, and Erdman Creeks are accessible to deer for drinking. Migratory fish such as suckers can swim up Buttermilk Creek beyond the entrance of Erdman Brook.

Another source of liquid waste is from two holding lagoons at the burial site located upstream from the reprocessing plant on Franks Creek. Rain water that has entered an open trench is pumped into a holding lagoon in order to provide dry working conditions in the open end of the trench. Radioactive materials from previously deposited crushed containers are leached out and significant concentrations of various radionuclides have been found in the holding lagoons. These radionuclides are pumped into Franks Creek at a controlled rate after analysis.

The revised safety analysis report (*2*) submitted by the company in August 1964, estimated that the gross radioactivity in Cattaraugus Creek would be about 0.1 pCi/liter, exclusive of tritium. The surveillance program of the State Health Department initially concentrated on vectors affected by airborne releases originating from the stack. A single water sampling station was established on Cattaraugus Creek as a check on operations. It was not originally planned to do extensive studies on wildlife, fish, and silt, because at the concentrations predicted in the saftey analysis, the possible reconcentration of radioactivity in fish and wildlife was not expected to be a problem.

The company first started to dissolve fuel in April 1966, beginning with fuel that had little burn-up and progressing to spent fuel with more normal burn-up by August 1966. Beginning in September 1966, curie quantities of radioactive materials were being discharged to Franks Creek each month.

Effects of stack discharges

In order to determine the possible effects of stack discharges on the environment, the State Health Department has monitored air and milk supplies in the surrounding area and has reviewed the stack discharges reported by the company. In addition, gamma radioactivity has been meas-

Table 1. Gross beta radioactivity in air particulate samples, 1965–1967

Site number		Concentration (pCi/m³)		
		1965	1966	1967
20	Average	<1	<1	<1
	Maximum	<1		
12	Average	<1		
	Maximum	<1		
2	Average	<1		
	Maximum	1		
11	Average	<1		
	Maximum	1		
4	Average		<1	<1
	Maximum		<1	<1
14	Average		<1	<1
	Maximum		<1	<1
43	Average		<1	<1
	Maximum		<1	<1
44	Average		<1	<1
	Maximum		1	<1
45	Average		<1	<1
	Maximum		1.1	1
Statewide: [a]				
	Average	<1	<1	<1
	Maximum	2	2	1.5

[a] Excludes samples from NFS area.

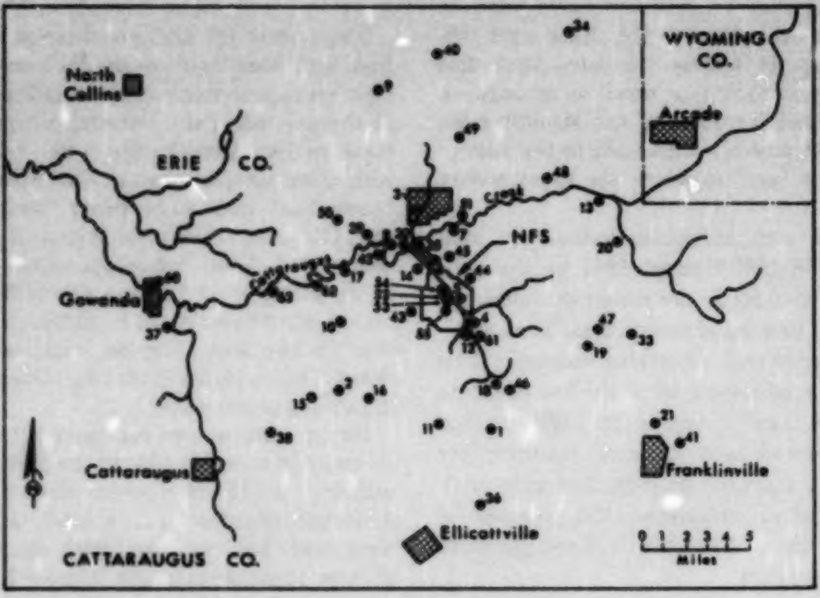

Figure 2. New York State Surveillance Program for Nuclear Fuel Services Facility, site numbers, and locations, 1965–1966

ured at 30 different sites, using a pressurized ionization chamber. The locations of the sampling stations by number are shown in figure 2.

Air samples are taken continuously at 5 different locations for a 7-day period, using a 2-inch glass-fiber filter at an air-flow rate of 1.1 cfm. These samples are analyzed for gross beta radioactivity. In the statewide surveillance program, a value below 1.0 pCi/m³ was not considered significant because of fluctuations in fallout caused by occasional atmospheric weapons test. The decline in fallout as a result of the limited test-ban treaty has allowed better comparisons of air concentrations below 1.0 pCi/m³. A summary of the air results and a comparison with the statewide average is given in table 1. Table 2 presents a summary and an explanation of air results greater than 0.3 pCi/m³ for the NFS site for the years, 1966–1967. If reasonable dilution factors for each site are considered, the volume of air sampled is not large enough to provide the sensitivity required to detect the maximum rate of particulate radioactivity that is allowed to be discharged.[8]

Table 2. Radioactivity in air samples at Ashford, N.Y. 1966–1967

Site number and location		Collection dates	Gross beta (pCi/m³)	Explanation
		1966		
4	Buttermilk Creek at Fox Valley Road bridge	6/22– 6/28	0.37	(a)
		8/24– 8/30	.32	(b)
		11/ 9–11/15	.34	(c)
		11/16–11/22	.34	(c)
14	Walter Feus farm near Edies siding	5/10– 6/16	.55	(a)
		6/17– 6/23	.55	(a)
43	Harmon Houri's farm 2 miles S.W. of NFS	8/16– 8/22	.33	(b)
		11/ 8–11/14	.69	(c)
44	Devere Zafer's farm on county road 32, 1.5 miles north of Riceville	11/ 3–11/ 9	1.03	(c)
		11/10–11/16	.32	(c)
		12/ 1–12/ 7	.32	(c)
45	Robert Emerson's farm on Thomas Corners Road	6/25– 7/ 1	.47	(a)
		11/ 4–11/10	1.12	(c)
		11/19–11/25	.88	(c)
		1967		
14	Walter Feus farm	12/14–12/21	.33	(d)
43	Harmon Houri farm	12/10–12/21	.53	(d)

[a] A Chinese nuclear explosion in the atmosphere occurred on May 9, 1966.

[b] A French atmospheric nuclear explosion occurred in the Atolls on May 2, 1966.

[c] A Chinese atmospheric nuclear test occurred on August 28, 1966.

[d] The Environmental Radiation Surveillance Report No. 3, March 11, 1968 prepared by the Standards and Intelligence Branch, National Center for Radiological Health, PHS, showed that during the period, December 12–21, 1967, slightly higher than normal readings occurred at many of the air sampling stations in the United States. It is believed that the slightly higher readings found in the NFS area were caused by residual radioactivity in the atmosphere from weapons testing and not from stack discharge.

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[8] Title 10, Part 20 of the Code of Federal Regulations.

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However, past experience in the State with fallout from weapons testing indicates that this method of air sampling is sensitive enough to predict significant increases in the strontium-90, cesium-137, and possibly iodine-131 in the milk of cows grazing on land on which the radioactivity may accumulate.

The average and maximum values for milk samples taken in 1965 through 1967 for the NFS area are given in table 3; the statewide values are also shown for purposes of comparison. The iodine-131 data indicate no detectable releases. This result was expected since most of the fuel elements processed were aged. Starting in 1967, an ion exchange procedure and separate counting for iodine-131 was adopted for milk, but even with the more sensitive procedure, the presence of iodine-131 in milk attributable to discharges from NFS was not detected.

The cesium-137 and strontium-90 in cows' milk from individual herds in the NFS area were not of high enough concentration to indicate that stack discharges made any detectable contributions of these radionuclides to the milk. For comparison with other sample taken in the State, it should be noted that individual herds were sampled in the NFS area, while most statewide samples were composited. Even before operations were started at the plant, some farms in the NFS area showed higher strontium-90 and cesium-137 concentrations in the milk than did most stations in the State. This is probably attributable to differences in farming practices (*3*).

Background gamma radioactivity readings were taken at 30 different sites in the NFS area in 1964, utilizing a Reuter-Stokes RSG-9 pressurized ionization chamber (*4*). In 1967, repeat readings were made and compared with concurrent values in other areas of the State. The 1967 data indicate

Table 3. Milk samples, 1965–1967

Location site number		Concentration (pCi/liter)								
		1965			1966			1967		
		^{90}Sr	^{131}I	^{137}Cs	^{90}Sr	^{131}I	^{137}Cs	^{90}Sr	^{131}I	^{137}Cs
2	Average	NS	NS	NS	12.5	<20	20.5	11	<5	16
	Maximum	NS	NS	NS	18.0	<20	53.0	16	6	25
13	Average	25.5	<20	74.4	20.0	<20	31.2	12	<5	20
	Maximum	34.0	<20	86.1	27.0	49.3	68.7	14	9	36
14	Average	15.3	<20	94.5	14.8	<20	21.1	12	<5	25
	Maximum	19.0	<20	112.3	20.9	32.2	58.6	16	<5	47
31	Average	NS	NS	NS	NS	NS	NS	11	<5	27
	Maximum	NS	NS	NS	NS	NS	NS	18	<5	56
43	Average	NS	NS	NS	24.6	<20	32.9	19	<5	23
	Maximum	NS	NS	NS	39.1	53.4	72.3	26	5	31
45	Average	NS	NS	NS	17.7	<20	32.5	13	<5	29
	Maximum	NS	NS	NS	30.7	47.9	76.9	17	6	49
46	Average	NS	NS	NS	17.1	<20	34.5	13	<5	25
	Maximum	NS	NS	NS	27.7	40.3	79.2	23	8	62
47	Average	NS	NS	NS	15.1	<20	50	14	<5	26
	Maximum	NS	NS	NS	18.8	<20	115.8	19	10	56
48	Average	NS	NS	NS	9.3	<20	19.8	6	<5	22
	Maximum	NS	NS	NS	13.0	32.8	43.9	11	14	38
49	Average	NS	NS	NS	4.4	<20	27.5	14	<5	27
	Maximum	NS	NS	NS	19.0	<20	51.6	29	6	52
50	Average	NS	NS	NS	6.9	<20	30.5	14	<5	26
	Maximum	NS	NS	NS	19.0	<20	68.6	29	<5	65
51	Average	NS	NS	NS	5.3	<20	28.8	22	<5	18
	Maximum	NS	NS	NS	19.3	<20	53.6	50	7	42
68	Average	NS	NS	NS	NS	NS	NS	12	<5	21
	Maximum	NS	NS	NS	NS	NS	NS	20	7	35
Statewide:[a]										
	Average	14.3	<20	51.3	9.9	<20	29.6	7.6	<5	<20
	Maximum	30.0	59.2	165.3	30.0	49.0	118.0	31.0	10.0	60

[a] Excludes samples from NFS area.
NS, no sample.

that the decrease in the NFS area was not as great as the decrease in background in other areas of the State. The differences were extremely small and could not be directly related to stack releases. This phase of the study is being continued through 1969 and will be reported at a later date.

The data obtained through 1967 indicate that the stack discharges have not produced effects on the environment that might represent a public health hazard. The State Health Department, in cooperation with the U.S. Public Health Service, has been attempting to develop an economical means of monitoring for krypton-85 and other gaseous beta-particle emitters. Monitoring was not conducted during the 1965-1967 period to ascertain the presence of krypton-85 outside the fence line.

Effects of liquid waste discharges

A summary of liquid waste discharges reported by the company (*5*) is given in table 4. To a certain extent, the wastes were released in proportion to the flow in Cattaraugus Creek. Examination of tables 5, 6, and 7, and figure 4 indicate some general characteristics.

1. Higher concentrations of strontium-90 were found in Cattaraugus Creek in the fall and winter of 1966–1967 than were found in the latter part of 1967. Strontium-90 represents a significant part of the total gross beta radioactivity.

2. Cesium is removed in greater quantities in silt than strontium; most of the strontium-90 is found in the dissolved state.

3. The ratio of cesium-137 to cesium-134 in the wastes is about 4 or 5 to 1. Cesium-134 is indicative of spent fuel and is not a significant component of fallout from weapons testing.

Data on samples taken from the discharge of waste lagoon 3 are given in table 5.

The average and maximum values for radioactivity found in Buttermilk and Cattaraugus Creeks are summarized in table 6. Figures 3 and 4 show the average monthly concentrations of gross beta radioactivity and of strontium-90, respectively, in Cattaraugus Creek at Springville Dam (site 42 on figure 2). This is a State operated, continuous-sampling site, 2 miles downstream from Buttermilk Creek. The results show that the maximum limit allowed for strontium-90 by the AEC (300 pCi/liter) was not exceeded.

Values for silt samples are shown in table 7. A study of silt behind Springville Dam was made in June 1967. As might be expected, the larger particles near the inflow to the pond contained less radioactivity per unit weight than the smaller particles in the center of the pond.

Table 4. NFS monthly liquid waste discharge

Month	Volume (gallon)[a]	Total radioactivity released[b]		
		Alpha radioactivity (Ci)	Beta radioactivity (Ci)	Tritium (Ci)
1966				
February	200,000	6.3×10^{-4}	3.7×10^{-4}	0.73
March	1,200,000	1.5×10^{-4}	7.2×10^{-4}	2.46
April	587,000	1.8×10^{-6}	2.5×10^{-3}	.12
May	4,452,500	5.0×10^{-6}	9.0×10^{-3}	12.6
June	1,813,000	8.3×10^{-4}	2.0×10^{-1}	6.8
July	4,200,000	1.6×10^{-6}	1.4×10^{-1}	8.0
August	1,950,000	7.4×10^{-6}	2.2×10^{-1}	44.0
September	4,230,000	5.6×10^{-6}	2.5	160.0
October	2,934,000	2.9×10^{-6}	2.6	20.0
November	2,500,000	1.8×10^{-6}	1.1	13.0
December	3,061,000	1.5×10^{-5}	1.4	25.0
1967				
January	3,620,000	1.1×10^{-5}	4.1	300
February	4,000,000	4.0×10^{-6}	2.3	500
March	2,530,000	7.4×10^{-6}	1.5	280
April	1,650,000	2.3×10^{-6}	0.6	94
May	2,400,000	8.4×10^{-6}	1.7	500
June	2,000,000	1.6×10^{-6}	1.3	620
July	3,800,000	2.5×10^{-4}	1.5	650
August	2,400,000	0	1.4	270
September	2,700,000	2.9×10^{-6}	1.3	460
October	3,220,000	1.5×10^{-6}	2.4	340
November	2,770,000	1.3×10^{-6}	5.4	[illegible]
December	2,980,000	1.3×10^{-5}	7.2	[illegible]

[a] Calculated by NFS as 1,240,000 gallons per month in original safety analysis report.
[b] Limit 48 curies per quarter exclusive of tritium.

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Table 5. Radioactivity in water samples from waste lagoon

Radioactivity (pCi/liter)[a]	Grab sample collected 1/29/67	Composite samples collected 6/67	Grab sample collected 7/67	Grab sample collected 9/8/67
Gross beta radioactivity				
Suspended	72,000	20,660	2,502	NA
Dissolved	348,000	230,490	98,283	NA
Strontium-90				
Suspended	88,000	203	60	[b]4,050
Dissolved		59,600	14,400	
Tritium	45,000,000	NA	NA	[b]91,000,000
Uranium (ppm by weight)	19.3	NA	NA	NA
Cobalt-60	2,000	NA	[b]260	[b]2,700
Ruthenium-106	227,000	NA	[b]43,000	[b]230,000
Cesium-134				
Suspended	15,000	NA	[b] 150	[b]24,000
Dissolved		NA	[b]1,100	
Cesium-137				
Suspended	63,000	NA	[b] 580	[b]61,000
Dissolved		NA	[b]5,700	
Iodine-129	NA	750	NA	NA
		Grab sample 6/14/67		
Antimony-125	NA	NA	[b]6,700	[b]20,000

[a] All concentrations are in units of pCi/liter except for uranium which is in units of ppm.
[b] Data from U.S. Public Health Service.
NA, no analysis.

A limited number of samples were examined to determine the presence of plutonium and uranium in the effluent and in local streams. The results, summarized in table 8, indicate that these radionuclides were not present in sufficient amounts to cause concern; however, they should be determined periodically in the future because of the variability of waste discharges.

Deer and fish sampling results are given in tables 9 and 10. The 3,300-acre site is surrounded by a 3-foot-high fence, and a 10-foot-high exclusion fence surrounds an area of 90 acres around the main part of the plant and burial site. Deer taken in 1966 were from the general NFS area outside the site perimeter fence. The deer samples taken inside the exclusion fence in December 1967

Table 6. Radioactivity in water samples

Site number and location	Concentration (pCi/liter)							
	1965		1966		1967			
	^{90}Sr	Gross beta	^{90}Sr	Gross beta	^{90}Sr	^{137}Cs	Gross beta	Tritium
4 Buttermilk Creek, upstream								
Average	<3		<3	2	<3	<20	6	1,570
Maximum	<3		<3	3	<3	<20	13	2,900
7 Cattaraugus Creek, upstream								
Average	<3		<3	2.5	<3	<20	5	1,860
Maximum	<3		<3	3	8	50	10	4,500
35 Buttermilk Creek, downstream								
Average	<3		[a]<3	[a]5.8	335	112	970	320,430
Maximum	<3		<3	15	1,305	506	4,068	1,452,000
42 Cattaraugus Creek, downstream								
Average	<3		62	116	24	<20	95	30,730
Maximum	<3		265	1,387	53	77	315	183,170
60 Cattaraugus Creek, downstream (Gowanda)								
Average	<3						52	21,510
Maximum	<3						157	100,950
65 Cattaraugus Creek, downstream (Irving Bridge)								
Average	<3						51	24,710
Maximum	<3						112	82,670
Statewide								
Average	<3	[b]11.7	[b]<3	[b]5.3	<3	<20	6	2,280
Maximum	9	[b]60	[b]5.6	[b]34	<3	<20	103	7,200

[a] Samples from Buttermilk Creek were not taken during period of discharge from Nuclear Fuel Services for latter half of year 1966.
[b] Fresh water samples excluding those collected from the Nuclear Fuels Services area.

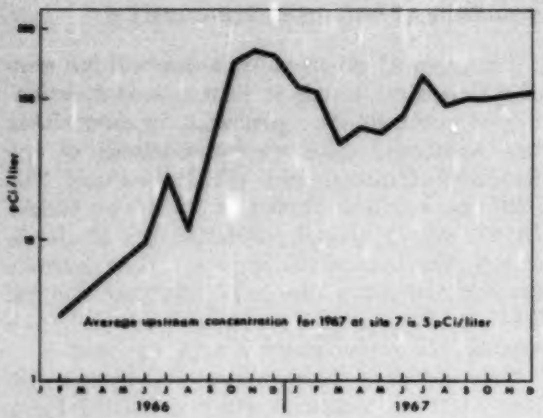

Figure 3. Gross beta concentrations at Springville dam site 42 - monthly averages, 1966–1967

are significantly higher in radioactivity, probably as a result of drinking contaminated water. There were two or three openings in the exclusion fence caused by stream erosion and deer had access to 2-½ miles of contaminated water in Buttermilk, Erdman, and Franks Creeks not protected by the exclusion fence.

The results of fish sampling reflect the three characteristics of wastes cited previously. The strontium-90 concentrations were high. Whole, uncleaned fish were analyzed; no attempt was made to analyze the flesh, bone, scales, and intestines separately. Most of the fish, obtained by shocking, were suckers, which are bottom feeders. Studies performed in the Clinch River (7) where similar wastes were discharged, showed that bottom feeders could have more strontium-90 than cesium-137 in the flesh. This relationship is unlike that in game fish, where the cesium-137 in flesh was higher. Suckers are taken from Cattaraugus Creek for food, especially in the springtime. In addition, there may be a practice of grinding up the flesh and bone to make fishburgers.

Table 7. Radioactivity in silt samples

Site number and location	Collection date	Concentration (pCi/g dry weight)					
		^{90}Sr	^{137}Cs	^{106}Ru	^{134}Cs	^{95}Zr-Nb	^{60}Co
35 Buttermilk Creek, downstream	8/29/66		74	47		88	6.3
	11/30/66	81	179	589		222	9.2
	2/27/67	3.9					
	3/ 6/67	4.8					
	3/20/67	.4					
	3/27/67	1.4					
4 Buttermilk Creek, upstream	11/30/66	.3	.2	1.7		.2	.1
	2/27/67	.1					
	3/ 6/67	.1					
	3/13/67	.2					
	3/20/67	< .01					
	3/27/67	< .01					
42 Cattaraugus Creek, downstream (Springville dam)	11/30/66	3.8	9	32		10.7	.4
	1/27/67		4.3	4.5	1.5	.8	.3
	2/28/67	1.2					
	3/ 7/67	9.9					
	3/14/67	.9					
Location A[a]	6/ 5/67[b]	.3	8.1	1.9	1.4		.2
B[a]	6/ 5/67[b]	.6	4.5	1.3	.8		.2
C[a]	6/ 5/67[b]	1.9	37.3	2.6	7.1		.4
D[a]	6/ 5/67[b]	2.5	44.4	2.8	5.2		.4
E[a]	6/ 5/67[b]	1.8	43.3	3.4	7.6		.5
F[a]	6/ 5/67[b]	1.2	19.4	3.5	3.5		.4
32 Cattaraugus Creek, downstream (Felton bridge)	9/28/66		6.5	22		6.7	.6
	11/30/66	4.6	8.3	28.3		9.5	.5
	3/ 7/67	.1					
	3/14/67	.6					
7 Cattaraugus Creek, upstream (Bigelow bridge)	9/28/66		.3	1.9		.2	.1
	11/30/66	1.6	< .1	< .9		< .1	< .1
	3/ 7/67	.6					
	3/14/67	.1					
	3/21/67	< .01					
	6/13/67[b]		.09				
5-mile Creek, south	1/27/67		.4	2.5		.4	
Cattaraugus County (background):							
61 Buttermilk Creek upstream, Pfeffer's Pond (background)	8/29/66		.7	7		.9	.6
52 Waste lagoon #3	1/29/67		11,100	18,700		11,100	1,700
	9/ 8/67[c]	770	11,100	2,900	2,400		74

[a] Locations A–E were taken through the center of the pond perpendicular to the dam; A was located at the upper end of the pond approximately 2,500 feet from the face of the dam; B, approximately 2,000 feet from the face of the dam; C, approximately 1,500 feet; D, approximately 1,000 feet; and E, approximately 500 feet. Location F was near the entrance to the penstock, about 60 feet from the face of the dam and 5 feet from the north shore.

[b] Data on gamma-ray emitters from the U.S. Public Health Service.

[c] Data from U.S. Public Health Service.

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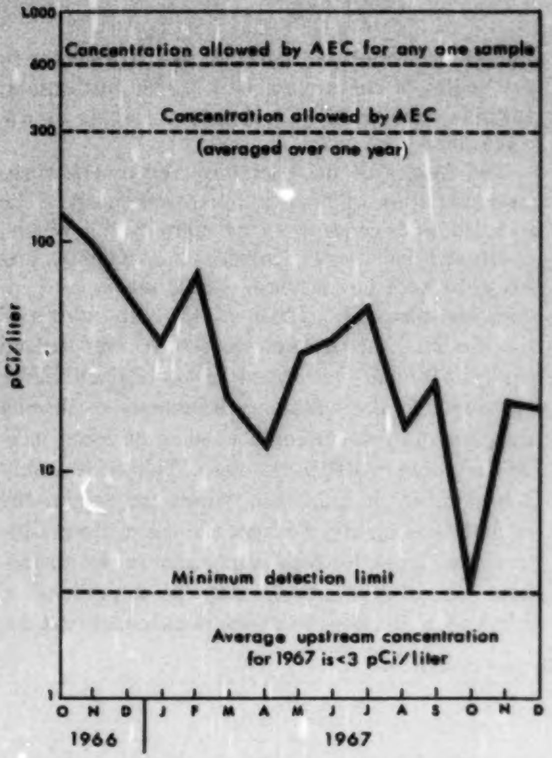

Figure 4. Strontium-90 concentrations in Cattaraugus Creek at Springville dam site 42

Significance of radioactivity in deer and fish

The levels of radioactivity in deer and fish were of sufficient magnitude to require careful evaluation of public health significance. In ascertaining this significance, the recommendations of the Federal Radiation Council (FRC) were used. The FRC has set forth Radiation Protection Guides (RPG) (*8*) for normal peacetime uses of atomic energy. For both whole body and bone marrow, the RPG for individuals is 0.5 rem/year, and the RPG for the average of a suitable sample of the exposed population group is 0.17 rem/year.

Calculations of the amount of deer meat or fish that could be consumed within the RPG limits were based on the following assumptions, which are considered to be conservative in terms of public health.

1. The highest levels of radioactivity found in fish and deer meat were used.
2. The RPG for an individual was used because it is unlikely that a large number of people would eat deer meat or fish, each having the highest level of radioactivity.
3. FRC Report No. 7 (*9*) was used as a reference to calculate exposure from ingestion of cesium-137. In this report, the dose to the whole body for an

Table 8. Plutonium and uranium in water and silt samples

Site number and location	Date	Concentration in water[a] (pCi/liter)				
		^{238}Pu	^{239}Pu	^{234}U	^{235}U	^{238}U
42 Cattaraugus Creek at Springville Dam, downstream	10/25/66	0.023	<0.01	0.26	<0.002	0.19
	11/ 1/66	.063	< .02	.23	< .005	.41
	11/22/66	< .02	< .02	.44	< .12	< .01
	11/29/66	< .03	< .01	.18	< .06	.17
	1/ 3/67	< .5	< .5	.15	.11	.09
	1/10/67	1.16	.7	.15	< .02	.15
	[b]6/13/67	ND	ND	NA	NA	NA
7 Cattaraugus Creek at Bigelow Bridge, upstream	10/25/66	< .02	< .01	.10	< .01	.12
	11/ 1/66	.06	< .03	.16	< .007	.07
	11/22/66	< .03	.01	.16	< .008	< .01
	11/29/66	< .02	< .02	< .33	< .15	< .01
	[b]6/13/67	ND	ND	NA	NA	NA
52 Waste lagoon #3	[b]9/ 8/67	16	32	242	NA	112
		Concentration in silt (pCi/g)				
52 Waste lagoon #3	[b]1/29/67	39.3 (total plutonium)		ND (total uranium)		
	[b]9/ 8/67	3.1	4.7	8.8	NA	8.8
42 Cattaraugus Creek, Springville Dam	[b]6/13/67	ND	.03	.63	NA	.99

[a] Less than values are minimum detectables levels for State samples. Minimum detectables levels are determined by the amount of solids in the sample.

[b] Data by U.S. Public Health Service.

NA, no analysis.

ND, nondetectable.

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Table 9. Radionuclides in soft tissues of deer

Sample number	Place taken	Date	Sample organs	Cesium-137 (pCi/kg)	Cesium-134 (pCi/kg)	Tritium (pCi/kg)
66-1	Otto	9/66	Stomach	150		
			Lungs	50		
66-2	Ashford		Stomach	100		
			Liver	100		
			Lungs	80		
66-3	E. Otto		Stomach	70		
			Lungs	150		
66-4	Mansfield		Stomach	160		
			Liver	140		
67-1	Within NFS plant perimeter	1/23/67	Lungs	490	120	
67-3				195	40	
67-1		1/23/67	Heart	580	130	
67-2				200	<40	
67-3				490	95	
67-1		1/23/67	Liver	210	65	
67-2				150	40	
67-3				<30	<30	
67-4				135	20	
67-1		1/23/67	Stomach	480		
67-2				300		
67-3				370		
67-B	Within NFS exclusion fence	12/13/67	G.I. tract	17,382	3,130	
			Lungs	19,249	3,592	
			Liver	26,797	4,438	
			Meat	66,056	11,276	41,800
67-C		12/13/67	G.I. tract	5,560	1,010	
			Lungs	17,567	2,829	
			Liver	14,796	2,500	
			Meat	64,449	12,313	39,800
67-D		12/13/67	Lungs	19,436	3,140	
			Liver	24,251	3,856	
			Meat	33,135	5,651	46,300
67-E	Limestone (background)	1/29/68	Lungs	92	0	
			Meat	261	0	1,380

Table 10. Radioactivity in sample of whole fish

Site Number	Location	Collection date	Concentration (pCi/kg raw weight)					
			^{106}Ru	^{134}Cs	^{60}Co	^{137}Cs	^{40}K	^{90}Sr
4	Buttermilk Creek, upstream (Fox Valley Road)	[a]6/13/67	6.7	6.6		54	2,470	106
		[b]6/13/67						[b]2,640
		10/27/66						153
		10/27/65		16		79		
		6/22/65				5		
		10/ 7/64				58		
		6/30/64				<32		
35	Buttermilk Creek, downstream (Thomas Corners Road)	[a]6/13/67	1,730	5,750	340	27,500	5,190	15,300
		[b]6/13/67						[b]3,200
		10/27/66						81
		10/27/65		870	277	1,685		
		6/22/65				33		
7	Cattaraugus Creek, upstream (Bigelow Bridge)	[a]6/13/67	88	100	19	871	2,000	875
		[b]6/13/67						[b]34
		10/27/66						12,350
		10/27/65				21		
		6/22/65				23		
32	Cattaraugus Creek, downstream (Felton Bridge)	[a]6/13/67	490	796	25	3,610	3,080	906
		[b]6/13/67						[b]137
		10/27/66						1,035
		10/27/65		244	46	455		
		6/22/65				19		
		10/ 7/64				<32		
		6/30/64				<64		
62	Cattaraugus Creek, downstream (Frye Bridge)	[a]6/13/67	280	348	32	1,570	3,170	564

[a] Data for this collection date by U.S. Public Health Service.

[b] Samples received in decomposed state and were ashed without obtaining raw weight. A ratio of 1.5 percent ash weight was used to convert from ashed weight to raw weight on basis of similar fish samples.

adult weighing 70 kg, from the ingestion of 1 microcurie of cesium-137, was estimated as 0.06 rad. The dose from ingestion of cesium-134 was determined by multiplying the dose per microcurie of cesium-137 by a factor of 1.87, the ratio of energy release per disintegration of cesium-134 compared to cesium-137.

4. FRC Report No. 2 (*8*) indicates that the ingestion of 200 pCi of strontium-90 per day per gram of dietary calcium generally corresponds to one-third of the appropriate RPG averaged for an exposed population group; therefore, since the daily calcium intake is about 1 g per day, the exposure to bone marrow is based on the assumption that ingestion of 600 picocuries of strontium-90 per day results in a dose of 0.17 rad/year.

5. Exposure from the ingestion of tritium was calculated from recommedations of the National Council on Radiation Protection and Measurement (NCRP) and was used to illustrate the principle of considering total exposure from all radionuclides present. Although the exposure from tritium was extremely small, all possible sources must be considered in the accumulated exposure.

6. The critical organ for strontium-90 ingestion is bone marrow; for cesium-137, cesium-134, and tritium, it is the whole body. In determining allowable consumption of fish based on bone marrow, the concentrations from the two cesium isotopes were conservatively added, based on whole body exposure.

7. No analysis was made for strontium-90 in deer meat, but it could contribute additional exposure to the bone marrow of a person eating both deer meat and fish.

8. The fish data represent measurements for unscaled and ungutted samples. A conservative assumption was made that the concentration of strontium-90 in the edible parts of the fish was the same as for the entire fish. In the future, separate analysis of the edible portion of the fish will be made to provide information on how conservative this assumption was.

The calculations for allowable consumption of deer meat and fish are in table 11.

If fish were the only source of exposure, the amount of fish that could be consumed without exceeding the RPG was calculated as 78 pounds per year. The amount of deer meat that could be consumed, if this were the only source of exposure, was calculated as 220 pounds per year. Deer within the exclusion area are not readily accessible to hunters and the possiblity of many deer being scared out of the exclusion area and the site seems remote. The fish appear to reconcentrate the radioactivity, have ready access to the streams, and represent the more critical pathway for human exposure.

Table 11. The calculations for allowable consumption of deer meat and fish

Nuclide	Concentration (μCi/kg)	Exposure (rads/μCi)	Dose (rad/kg)
Deer meat[a]			
Cesium-137	0.067	0.06	0.00402
Cesium-134	.011	.11	.00121
Tritium	.040	.0002	.000008
Total			0.00524
Fish (suckers)[b]			
Strontium-90	0.0153	.78	0.0120
Cesium-137	.0275	.06	.0016
Cesium-134	.005	.11	.0006
Total			0.0142

[a] Allowable consumption of deer meat for an adult (based on whole body exposure). $= \frac{0.5 \text{ rad/yr}}{.005 \text{ rad/kg}}$

= 100 kg/yr = 220 pounds/yr.

[b] Allowable consumption of fish for an adult (based on bone marrow exposure). $= \frac{0.5 \text{ rad/yr}}{.014 \text{ rad/kg}}$

= 35.7 kg/yr = 78 pounds/yr.

If additional consideration is given to the possibility that the plant may eventually discharge up to the limits allowed, and if exposures to an individual from other sources such as krypton-85 are added to the total accumultated exposure, there is a possibility that the RPG may be exceeded. In order to assure that the RPG will not be exceeded and to reduce the risk to health, certain actions have been taken.

Discussion

The New York State Health Department has taken actions which are in conformance with recommendations of the Federal Radiation Council. In December of 1966, the unexpected concentrations of strontium-90 in Cattaraugus Creek were brought to the attention of NFS and the AEC. The data indicate that the company has made an effort to reduce the amount of strontium-90 in the streams. The Health Department also started to place more emphasis on stream surveillance.

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As the data on fish and deer became available, the possibility of these being the most critical pathways was established. Further sampling studies were planned in accordance with the FRC recommendation that additional sampling be conducted when it appears that the RPG may be exceeded. The company was asked to repair holes in the fence of the exclusion area to exclude deer from the waste storage lagoons.

The Department used the RPG as a measure of the public health significance and calculations indicated that an immediate public health hazard did not exist. However, the FRC philosophy that "every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable" (*8*) was considered and applied. The Health Department's concern over the levels of radioactivity in the liquid waste discharge has been discussed with representatives of the AEC which has required NFS to make significant reductions in the levels of radioactivity discharged to the watershed. The Health Department has increased the surveillance program around the NFS plant and will continue to evaluate the release of radioactivity to the environment.

Acknowledgement

The author would like to acknowledge the valuable advice and analytical services provided by the PHS Northeastern Radiological Health Laboratory, Winchester, Mass., particularly for the data in tables 5 through 11 where sample analysis was performed by them. Also acknowledged is the excellent analytical laboratory work performed by the Radiological Sciences Group of the New York State Health Department's Division of Laboratories and Research.

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A 5-Year Summary of the Regulatory Control of Radioactive Material in Arkansas

E. F. Wilson and D. D. Snellings, Jr.[1]

On July 1, 1963, the State of Arkansas entered into an agreement with the U.S. Atomic Energy Commission (AEC) establishing the Arkansas Radiological Health program. The agreement transferred regulatory control of all radioactive material, including fissionable material of less than critical mass quantity, from the Atomic Energy Commission to the State of Arkansas. The Arkansas State Department of Health, Division of Radiological Health, was designated as the responsible agency by Act 8 of the Second Extraordinary Session of the Arkansas Legislature in 1961. In addition to assuming the control of previously regulated material, the Division of Radiological Health now controls all sources of ionizing radiation (i.e., radiation machines and radium). It should be noted that prior to 1963 the use of radium had never been regulated and several instances of improper management and usage were reported on initial compliance inspections.

In assuming the regulatory control of radioactive material, the Arkansas State Department of Health, Division of Radiological Health, instituted a program of licensing and inspection of all users of regulated material with the ultimate goal of preventing, if possible, or reducing to an acceptable level, the exposure to ionizing radiation.

This report is a summary of regulatory activities of the Division of Radiological Health from 1964 through and including 1968. The early (1964) regulatory inspections did not include sufficient data pertaining to the occupational exposure of individuals to radiation; however, the noted deficiencies of records and radiation safety are well documented. In early 1967, the Division of Radiological Health prepared all previous data for electronic data processing, and currently all regulatory inspections, as well as licensing activities, are prepared for electronic data processing[2] on a routine basis.

Upon receipt of an application for a radioactive material license, a systematic evaluation of the applicant's qualifications, equipment, and facilities, is initiated to insure, if the license is granted, capability for compliance with the current standards of radiation protection. The evaluation is designed to detect and eliminate any deficiency that might result in an unnecessary exposure to both the licensee and general public. Licensing guides which are compatible with those used by the U.S. Atomic Energy Commission (AEC) aid in the evaluation of a license application. An onsite prelicensing visit is made if deemed necessary by the complexity of an application.

The Division of Radiological Health initiated licensing activities in July 1963 through the issuance of Arkansas licenses for radioactive material not previously regulated. Until 1965, AEC licenses were continued as valid Arkansas licenses until their individual expiration dates, at which time they were reissued as Arkansas licenses. Table 1 shows the total number of active licenses by year and type of installation.

Examination of the data reveals a marked increase in the number of medical institution licenses, which may be attributed to the licensing of radium and the expiration of AEC licenses. In 1964, a survey was initiated to locate all radium users within the State and subsequently 22 licenses were issued. Presently, there are 32 licenses issued for radium use. The increase in the number of State and Federal laboratory licenses in 1965 is due to the licensing of civil defense personnel who routinely use radioactive material

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[2] The data reduction and resulting statistical summary of this report were processed on an IBM System 360/20 computer.

Table 1. Compilation of licenses by year, 1963–1968

Year	Medical		College and University		Industrial firms		Federal and State lab		Other		Civil Defense user permit[a]		Total
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
1963	27	28.12	5	5.20	27	28.12	6	6.25	31	32.29	0	0	96
1964	23	41.07	5	8.92	20	35.71	6	10.71	2	3.57	0	0	56
1965	48	27.58	16	9.19	18	10.34	92	52.87	0	0	0	0	174
1966	53	23.76	17	7.62	28	12.55	125	56.05	0	0	0	0	223
1967	50	18.58	17	6.31	44	16.35	158	58.73	0	0	0	0	269
1968	55	29.96	16	7.84	57	27.94	12	5.88	0	0	64	31.37	204

[a] Initiated November 1968.

for instructional purposes in radiological monitoring instructors courses conducted throughout the State. As reflected in table 1, a program was initiated in November 1968 to issue "user-permits" to qualified civil defense personnal under a specific license currently held by the State Radiological Defense officer. These civil defense user permits are included in table 1 because they are reported to AEC as individual licenses.

Upon receipt of a license to use radioactive material, the licensee is required to comply with the "Rules and Regulations for the Control of Sources of Ionizing Radiation" and any special conditions set forth in the license. Compliance inspections are conducted at each licensee facility according to a priority system that is not based on user categories, but on the following parameters.

1. Type, composition and quantity of radioactive materal;
2. Location and use of radioactive material;
3. Particular health hazards involved with the radioactive material;
4. Established leak test intervals for radioactive sources.

The inspection priority system ranges from one inspection semiannually to one inspection within a 3-year period, depending on the particular license; each licensee is inspected at least once every 3 years.

Compliance inspections are performed by health physicists, who have received intensive training in the regulation and control of radioactive material, and each inspection is completely documented for further reference and action. If an item of noncompliance is found, the licensee acknowledges the deficiency and corrective action is required within 30 days. Followup inspections are conducted to review the corrective action of all major items of noncompliance.

During the 5-year period (1964–1968), 247 compliance inspections were conducted as shown in table 2 by broad categories of licenses.

Table 2. Inspection and enforcement data, 1964–1968

	Medical	Educational	Industrial Radiography	Industrial	Other	Total
Total number inspections	147	43	9	40	8	247
Form report—no answer required; deficiencies noted	142	41	9	40	8	240
Formal written notification of noncompliance—answer required	5	2	0	0	0	7
Number licenses in compliance at time of inspection	55	29	4	21	5	114
Percent licenses in compliance	37.4	67.4	44.4	52.5	62.5	46.2

Table 3 shows the total number of active licenses and the number of inspections conducted during a particular year. The discrepancy between the total number of licenses issued and the total number of inspections conducted is attributed to the presence of civil defense licensees, who are

Table 3. Number of licenses and inspections by year

Year	Total number of licenses	Total number of inspections
1964	96	21
1965	174	53
1966	223	49
1967	269	59
1968	204	65

not routinely inspected, as well as a large number of out-of-state licensees who enter the State on a very limited basis. Medical licensees, both private practice and medical institutions, comprise approximately 59.9 percent of the total number of inspections. This large percentage results from the fact that all medical licenses, with the exception of three, are inspected annually, while the majority of the other catagories are inspected less often because they are of a less critical priority, or are out-of-state licenses, or are not actively engaged in operations involving radioactive material. The enforcement data also show that only about 2.84 percent of the compliance inspections required formal written notification of any major item of noncompliance noted during the inspection. The other 97.16 percent required only a form report which was completed at the time of the inspection. At the time of the inspection only 37.4 percent of the medical category were found to be in compliance with the regulations as opposed to 67.4 percent of the educational category that were in compliance. These results were to be somewhat expected because the medical licenses included a greater inventory of radioactive material and greater use factor. Although all industrial firms licensed to use radioactive material in the State are included in the overall statistics, many are actually out-of-state firms that enter only on a limited basis and this results in a limited number of inspections conducted on industrial radiography installations.

A compilation of the number of noncompliance items by license category is shown in table 4. All license categories average less than one violation per license over a 5-year period. The total number of violations incurred during the inclusive period was found to be 143.

Table 4. Number of noncompliance items by license category, 1964–1968

License category	Number of inspections	Number of licenses with:				Average violations per license
		1–3 violations	4–6 violations	7–9 violations	>9 violations	
Medical	147	67	2	1	0	0.75
Educational	43	6	0	0	0	.18
Industrial	40	10	0	0	0	.35
Industrial radiography	9	2	0	0	0	.44
Other	8	1	0	0	0	.12
Total	247	86	2	1	0	.57

The deficiencies noted on compliance inspections are categorically divided according to the Atomic Energy Commission's 'Agreement States Inspection and Enforcement Data" listing. Additional information about the deficiency is accumulated by subdividing the deficiency into a more detailed listing. For the purpose of this report only the AEC listing will be used.

As noted previously, a total of 143 deficiencies were found during the 5-year period. Frequency distribution tables have been prepared by type of deficiency and general license category. The deficiencies have been further divided into the following classificatons:

a. Administrative
b. Radiation safety
c. Personnel monitoring
d. Posting
e. Other

The total number of administrative-type deficiencies, shown in table 5, was found to be 37. Within this group it was found that medical licensees were deficient in all but one category and accounted for approximately 68 percent of the total number of deficiencies. The most widely found deficiences were the (1) improper record keeping of disposals and leak testing; and (2) possession of radioactive material not authorized by the license. Overall, the most frequently occurring deficiency of all license categories was the improper recording of leak test results, with the medical licensees incurring six of the deficiencies. Since this report has cited the medical licensees as accounting for the largest number of deficiencies, it should be noted that most hospitals and radiology groups possess a greater number of radioactive sources requiring periodic leak testing than do other licensees.

The deficiencies noted in the radiation safety category, as shown in table 6, accounted for 59 percent of the total number of deficiencies. During the 5-year period, 60 deficiencies involving the leak testing of sealed sources were discovered with the medical licensees accounting for approximately 87 percent of the deficiencies. The most probable reason or cause of the deficiency is the failure to perform the test; only in a few isolated cases were the tests performed in an unacceptable manner. The majority of the leak testing deficiencies occurred in medical installations that are licensed

Table 5. Administrative items of noncompliance by license category

Type deficiency	License category					Total
	Medical	Educational	Industrial radiography	Industrial	Other	
Improper records of leak testing	6	2	0	2	0	10
Records of surveys and disposal	6	1	0	0	0	7
Records of receipt and transfer	2	1	0	3	0	6
Possession of material without license	6	0	0	0	0	6
Regulations or operating procedures not available	2	0	0	2	0	4
Possession of unauthorized form or amount of material	2	0	0	0	0	2
Failure to report overexposures	1	0	0	0	0	1
Unauthorized use of material	0	0	0	1	0	1
Total	25	4	0	8	0	37

Table 6. Number of radiation safety items of noncompliance by license category

Type deficiency	License category					Total
	Medical	Educational	Industrial radiography	Industrial	Other	
Failure to leak test or improper leak test	52	3	0	4	1	60
Radiation survey not performed	11	0	0	0	0	11
Improper waste disposal procedures	5	0	0	0	0	5
Security of material in storage	1	0	0	0	0	1
Level of radiation in uncontrolled areas	0	0	0	1	0	1
Inventory not maintained or improper utilization logs	0	0	0	1	0	1
Total	70	3	0	5	1	79

to use radium-226. Because of the high frequency of leaking radium sources, the current leak test interval is on a 6-month basis, while the leak test interval on other types of sealed sources varies from 6 months to 3 years depending on the particular sealed source. Several times during the inclusive period, leaking radium sources were discovered during leak tests, the correction of which reduced contamination incidence. During the period, 1964–1968, several contamination incidents occurred which could possibly have been prevented if the leak tests had been performed as scheduled. Other incidents of failure to perform the leak test have occurred at educational institutions and industries; however, the frequency of these violations have been extremely low.

One serious incident occurred and was investigated by the Division of Radiological Health during the reported period. The incident involved the accidental dropping of a 194 curie cobalt-60 source during a source exchange operation. Prompt emergency actions by the individuals involved in the exchange resulted in the rapid evacuation of four floors of the multifloor office building and consequently no overexposures were recorded.

Table 7 shows those deficiencies dealing with personnel monitoring, posting, and unclassified deficiencies. These account for approximately 18.9 percent of the 143 total deficiencies shown on table 5. In general, the deficiencies noted are quite low considering the number of licensees and occupationally exposed personnel. The most frequently occurring deficiency during this period was the absence of caution signs and labels. The extent of the personnel monitoring of occupationally exposed personnel is shown in the data in table 8, which was obtained on 65 compliance inspections conducted in 1968. Overall, 97.3

Table 7. Number of personnel monitoring, posting and unclassified items of noncompliance by license category

Type deficiency	License category					Total
	Medical	Educational	Industrial radiography	Industrial	Other	
Improper personnel monitoring system	1	1	0	0	0	2
Improper personnel monitoring records	5	0	0	0	0	5
Absence of control device or signal	1	0	0	0	0	1
Absence of caution signs and labels	8	0	0	0	0	8
Absence of notice to employees signs	1	0	0	1	0	2
Other deficiencies not categorized	7	0	0	0	2	9
Total	23	1	0	1	2	27

percent of the 480 occupationally exposed personnel of the 65 installations are monitored by either a film badge service or personnel dosimetry or both.

Table 8. Personnel monitoring of 65 installations inspected in 1968

License category	Number occupationally exposed	Number Monitored
Medical	398	394
Educational	65	61
Industrial radiography	6	6
Industrial	5	5
Other	6	0
Total	480	466

Summary

The State of Arkansas has regulated the use of radioactive material for a 5-year period from 1964 through 1968. Data resulting from licensing and inspection activities for that period have been presented and examined. The accumulation and presentation of this data indicate that several items of noncompliance are recurring and will require greater emphasis on future compliance inspections. Particularly noted was the need for timely leak testing of sealed sources and the maintenance of adequate records of the test. Medical licensees, while constituting the large majority of the total licensees, have additionally incurred the largest percentage of violations.

It is anticipated that the compliance percentage, both overall and categorical, will increase in the future as a result of the educational nature of the compliance inspection.

Data

SECTION I. MILK AND FOOD

Milk Surveillance, April 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents

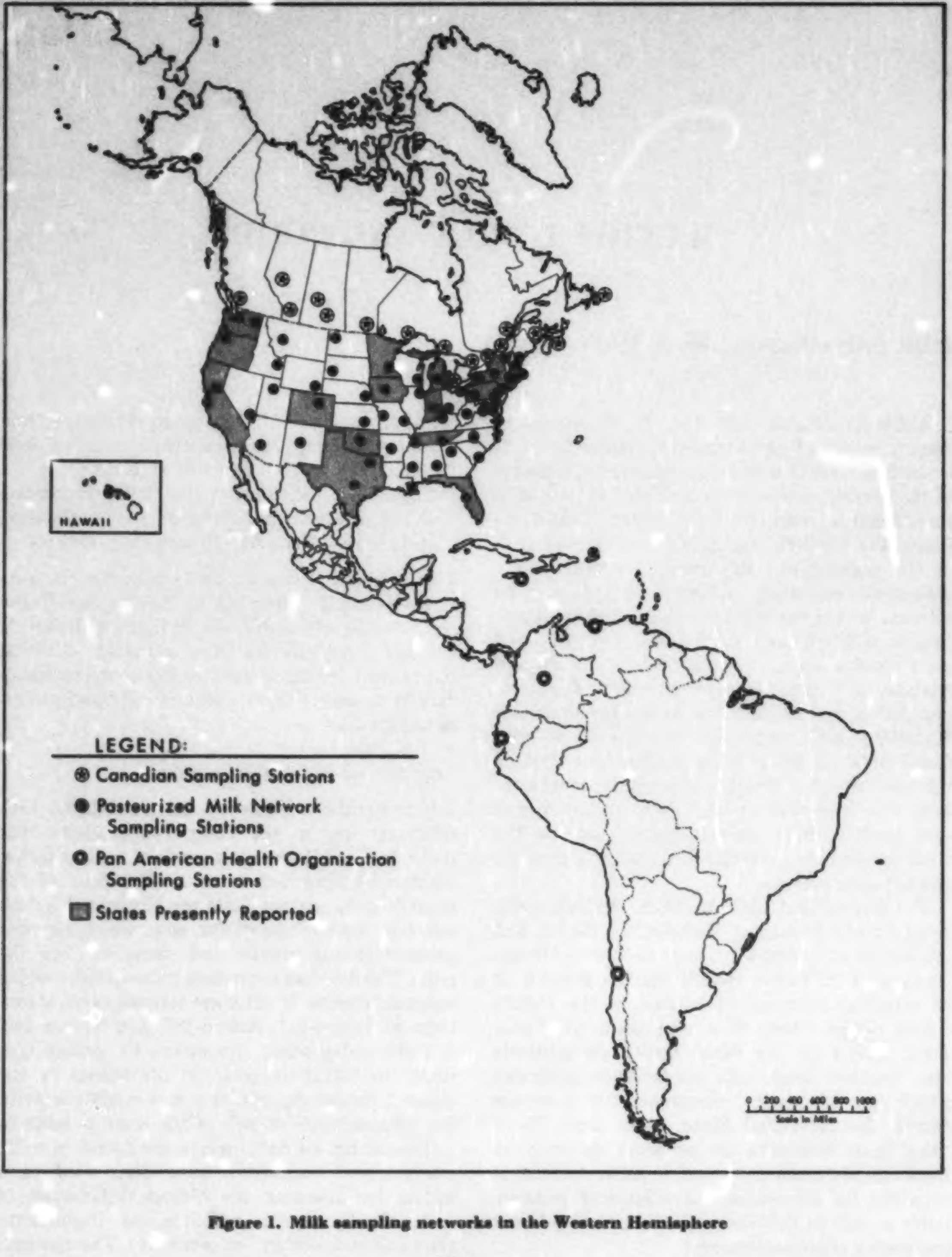
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
⊙ Pan American Health Organization Sampling Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3- standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases of 20 to 30 percent from the expected values (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Nuclide	Critical organ	RPG for individual in the general population (rad/yr)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/yr)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c].5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c].5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a one or two year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which, if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000
Strontium-90	Bone marrow			[c]51,000
Cesium-137	Whole body			[c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segement of the population.

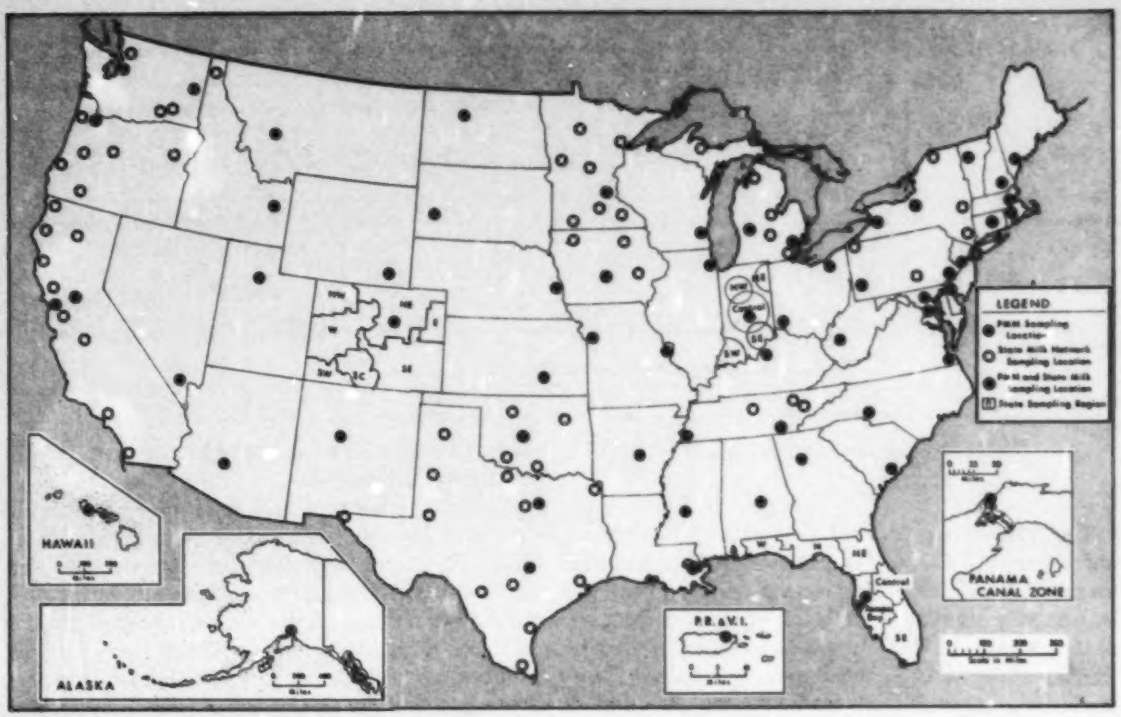

Figure 2. State and PMN milk sampling locations in the United States

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3 surveillance results are given for strontium-90, iodine-131, and cesium-137 for April 1969 and the 12-month period, May 1968 to April 1969. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for April 1969 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which strontium-89 and barium-140 were detected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of

Table 3. Concentration of radionuclides in milk for April 1969 and 12-month period, May 1968 through April 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	8	8	0 (4)	0	13 (4)	13
Alaska:	Palmer[c]	P	5	6	0 (2)	0	13 (2)	13
Ariz:	Phoenix[c]	P	3	0	0 (4)	0	0 (4)	1
Ark:	Little Rock[c]	P	22	21	0 (2)	0	16 (2)	19
Calif:	Sacramento[c]	P	3	1	0 (4)	0	0 (4)	2
	San Francisco[c]	P	5	1	0 (4)	0	3 (4)	3
	Del Norte	P	27	19	0	0	25	21
	Fresno	P	0	0	0	0	0	3
	Humboldt	P	8	4	0	0	14	12
	Los Angeles	P	0	1	0	0	0	4
	Mendocino	P	7	2	0	0	11	3
	Sacramento	P	3	2	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	6
	Shasta	P	5	3	0	0	13	6
	Sonoma	P	6	2	0	0	0	4
Colo:	Denver[c]	P	4	4	0 (3)	0	0 (3)	4
	West	R	(d)		(e)	(e)	(e)	(e)
	Northeast	R	(d)		NS	1	NS	(e)
	East	R	(d)		NS	(e)	NS	(e)
	Southeast	R	(d)		(e)	(e)	(e)	(e)
	South central	R	(d)		(e) (2)	(e)	(e)	(e)
	Southwest	R	(d)		(e)	(e)	(e)	(e)
	Northwest	R	(d)		NS		NS	
Conn:	Hartford[c]	P	8	9	0 (4)	0	15 (4)	12
	Central	P	6	8	0 (4)	0	8 (4)	10
Del:	Wilmington[c]	P	9	10	0 (5)	0	8 (5)	9
D.C.:	Washington[c]	P	9	9	0 (4)	0	0 (4)	6
Fla:	Tampa[c]	P	6	8	0 (4)	0	80 (4)	62
	West	R	11	12	0	3	24	26
	North	R	22	15	0	0	26	35
	Northeast	R	10	9	0	2	38	73
	Central	R	8	9	0	1	45	90
	Tampa Bay area	R	8	8	0	0	55	71
	Southeast	R	9	9	0	0	58	109
Ga:	Atlanta[c]	P	8	13	0 (4)	0	16 (4)	19
Hawaii:	Honolulu[c]	P	4	4	0 (4)	0	0 (4)	2
Idaho:	Idaho Falls[c]	P	5	6	0 (5)	0	9 (5)	9
Ill:	Chicago[c]	P	6	8	0 (4)	0	7 (4)	10
Ind:	Indianapolis[c]	P	8	8	0 (5)	0	0 (5)	6
	Northeast	P	7	11	0	0	0	12
	Southeast	P	4	10	0	0	5	12
	Central	P	9	9	0	0	10	10
	Southwest	P	7	9	0	0	10	10
	Northwest	P	8	9	0	0	10	12
Iowa:	Des Moines[c]	P	7	6	0 (4)	0	0 (4)	4
	Iowa City	P	10 (3)	7	0 (2)	0	10 (2)	8
	Des Moines	P	7 (5)	6	0 (4)	0	5 (5)	5
	Spencer	P	8	6	0	0	16	7
	Fredericksburg	P	10	10	0	0	0	0
Kans:	Wichita[c]	P	5	7	0 (4)	0	6 (4)	4
Ky:	Louisville[c]	P	9	12	0 (4)	0	5 (4)	7
La:	New Orleans[c]	P	17	19	0 (2)	0	23 (2)	21
Maine:	Portland[c]	P	10	12	0 (4)	1	20 (4)	26
Md:	Baltimore[c]	P	8	10	0 (4)	0	3 (4)	8
Mass:	Boston[c]	P	11	12	0 (5)	0	20 (5)	24
Mich:	Detroit[c]	P	8	9	0 (5)	0	10 (5)	11
	Grand Rapids[c]	P	9	11	0 (4)	0	14 (4)	15
	Bay City	P	NA	5	0 (2)	0	17 (2)	10
	Charlevoix	P	NA	7	0 (2)	0	19 (2)	12
	Detroit	P	5 (2)	5	0 (5)	0	8 (5)	5
	Grand Rapids	P	9	6	0 (4)	0	13 (4)	10
	Lansing	P	(a)	5	0 (2)	0	11 (2)	4
	Marquette	P	NA	9	0 (2)	0	27 (2)	28
	Monroe	P	NA	3	0 (2)	0	0	1
	South Haven	P	7 (3)	7	0 (4)	0	10 (4)	7
Minn:	Minneapolis[c]	P	8	11	0 (5)	0	10 (5)	14
	Bemidji	P	17	16	0	0	12	23
	Mankato	P	14	7	0	0	14	0
	Rochester	P	9	9	0	0	15	0
	Duluth	P	20	20	0	0	19	30
	Worthington	P	9	7	0	0	10	0
	Minneapolis	P	14	13	0	0	0	14
	Fergus Falls	P	11	10	0	0	10	11
	Little Falls	P	10	10	0	0	11	16
Miss:	Jackson[c]	P	11	15	0 (3)	0	20 (3)	16
Mo:	Kansas City[c]	P	9	7	0 (4)	0	0 (4)	3
	St. Louis[c]	P	7	9	0 (4)	0	5 (4)	3
Mont:	Helena[c]	P	6	4	0 (4)	0	3 (4)	8
Nebr:	Omaha[c]	P	7	6	0 (4)	0	3 (4)	4
Nev:	Las Vegas[c]	P	0	1	0 (5)	0	0 (5)	1

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for April 1969 and 12-month period, May 1968 through April 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.H.:	Manchester[c]	P	7	12	0 (5)	0	18 (5)	32
N.J.:	Trenton[c]	P	9	9	0 (5)	0	8 (5)	11
N.Mex:	Albuquerque[c]	P	4	2	0 (4)	0	0 (4)	2
N.Y.:	Buffalo[c]	P	7	8	0 (4)	0	12 (4)	10
	New York City[c]	P	11	12	0 (4)	0	12 (4)	15
	Syracuse[c]	P	8	9	0 (5)	0	8 (5)	9
	Albany	P	4	8	0	0	0	0
	Buffalo	P	NA	0	NA	0	NA	0
	Massena	P	9	11	0 (2)	0	0 (2)	21
	Newburg	P	5	11	0 (4)	0	0 (4)	0
	New York City	P	5	12	0 (4)	0	0 (4)	0
	Syracuse	P	4	8	11 (2)	0	0 (2)	0
N.C.:	Charlotte[c]	P	14	15	0 (3)	0	9 (3)	11
N.Dak:	Minot[c]	P	12	11	0	0	8	13
Ohio:	Cincinnati[c]	P	8	9	0 (5)	0	0 (5)	5
	Cleveland[c]	P	8	9	0 (4)	0	6 (4)	8
Okla:	Oklahoma City[c]	P	9	9	0 (4)	0	8 (4)	7
	Oklahoma City		NS					
	Enid		NS					
	Tulsa		NS					
	Lawton		NS					
	Ardmore		NS					
Ore:	Portland[c]	P	9	7	0 (4)	0	8 (4)	12
	Baker	P	NA	3	(e)	(e)	23	8
	Coos Bay	P	NA	9	(e)	(e)	(e)	15
	Eugene	P	NA	4	(e)	(e)	17	12
	Medford	P	NA	3	(e)	(e)	23	14
	Portland composite	P	NA	5	(e)	(e)	14 (4)	8
	Portland local	P	NA	5	(e)	(e)	(e) (4)	7
	Redmond	P	NA	3	(e)	(e)	19	6
	Tillamook	R	NA	7	(e)	(e)	23	27
Pa:	Philadelphia[c]	P	4	10	0 (3)	0	5 (3)	8
	Pittsburgh[c]	P	12	12	0 (4)	0	11 (4)	11
	Dauphin	P	6	8	NA		12	18
	Erie	P	3	11	NA		23 (2)	21
	Philadelphia	P	NS	10	NS		NS	17
	Pittsburgh	P	7	11	NA		9	15
R.I.:	Providence[c]	P	7	10	0 (5)	0	18 (5)	19
S.C.:	Charleston[c]	P	10	13	0 (4)	0	23 (4)	24
S.Dak:	Rapid City[c]	P	5	9	0 (3)	0	4 (3)	9
Tenn:	Chattanooga[c]	P	11	13	0 (3)	0	11 (3)	13
	Memphis[c]	P	10	11	0 (4)	0	9 (4)	6
	Chattanooga	P	12	11	0 (4)	0	17 (4)	17
	Clinton	P	12	13	0 (3)	0	16 (3)	18
	Knoxville	P	8	9	0 (2)	1	7 (2)	11
	Nashville	P	7	9	6 (2)	0	6 (2)	9
Tex:	Austin[c]	P	3	3	0 (3)	0	3 (3)	3
	Dallas[c]	P	7	8	0 (3)	0	8 (3)	7
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	NS	4	NS	0	NS	2
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	11	6	0	0	10	8
	Harlingen	R	NS	4	NS	0	NS	0
	Houston	R	9	9	0	0	20	19
	Lubbock	R	NS	10	NS	0	NS	2
	Midland	R	3	3	0	0	0	0
	San Antonio	R	NS	2	NS	0	NS	0
	Texarkana	R	NS	11	NS	0	NS	18
	Uvalde	R	2	2	0	0	0	0
	Wichita Falls	R	NS	9	NS	0	NS	2
Utah:	Salt Lake City[c]	P	5	5	0 (5)	0	11 (5)	11
Vt:	Burlington[c]	P	7	10	0 (4)	0	9 (4)	11
Va:	Norfolk[c]	P	11	11	0 (4)	0	11 (4)	10
Wash:	Seattle[c]	P	7	8	0 (4)	0	15 (4)	20
	Spokane[c]	P	8	7	0 (5)	0	4 (5)	8
	Benton County	R	NS	1	NS	0	NS	6
	Franklin County	R	3	1	0	0	0	0
	Sandpoint, Idaho	R	11	9	0	0	19	24
	Skagit County	R	10	5	0	0	0	12
W.Va:	Charleston[c]	P	8	12	0 (3)	0	9 (3)	8
Wisc:	Milwaukee[c]	P	7	7	0 (4)	0	14 (4)	12
Wyo:	Laramie[c]	P	5	5	0 (5)	0	5 (5)	11
CANADA:								
Alberta:	Calgary	P	5	8	(d)		16	18
	Edmonton	P	8	8	(d)		11	19
British Columbia:	Vancouver	P	10	13	(d)		31	45
Manitoba:	Winnipeg	P	8	8	(d)		17	24
New Brunswick:	Fredericton	P	10	15	(d)		11	21

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for April 1969 and 12-month period, May 1968 through April 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA (Continued)								
Newfoundland:								
	St. Johns	P	12	19	(d)		25	40
Nova Scotia:	Halifax	P	9	11	(d)		12	21
Ontario:	Ft. William	P	16	16	(d)		32	32
	Ottawa	P	9	9	(d)		15	19
	Sault Ste. Marie	P	16	15	(d)		24	34
	Toronto	P	6	5	(d)		7	15
	Windsor	P	6	8	(d)		6	14
Quebec:	Montreal	P	8	9	(d)		15	20
	Quebec	P	12	12	(d)		21	28
Saskatchewan:								
	Regina	P	6	7	(d)		13	17
	Saskatoon	P	5	9	(d)		12	18
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	NS	1	NS	0	NS	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Kingston	P	3	6	0	0	45	100
Venezuela	Caracas	P	NA	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	2	0 (4)	1	6 (4)	13
Puerto Rico:	San Juan[c]	P	4	5	0 (3)	0	8 (3)	7
PMN network average[f]			8	9	0	0	8	11

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones giving in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado–25 pCi/liter
Michigan–14 pCi/liter
Oregon–15 pCi/liter

Cesium-137: Colorado–25 pCi/liter
New York–20 pCi/liter
Oregon–15 pCi/liter
Washington–15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Table 4. Monthly average of strontium-89 and barium-140 in milk, April 1969

Sampling location	Radionuclide concentration (pCi/liter)	
	Strontium-89	Barium-140
Calif: Del Norte	19	
Santa Clara (State)		12
Shasta (State)		24
Idaho: Idaho Falls (PMN)		2(5)
Mo: Kansas City (PMN)		2(4)
Nebr: Omaha (PMN)		2(4)
Nev: Las Vegas (PMN)		3(5)
Tenn: Clinton (State)		4(3)

Strontium-90 monthly averages ranged from 0 to 27 pCi/liter in the United States for the month of April 1969 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark.,) representing 10.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 58 pCi/liter in the United States for the month of April 1969 and the highest 12-month average was 109 pCi/liter (Southeast Florida), representing 3.0 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level except Nashville, Tenn. (State) 6 pCi/liter, 2 samples.

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational, and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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FOOD AND DIET SURVEILLANCE

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	November–December 1967 and January–September 1968	May 1969
Connecticut Diet Study	January–June 1968	November 1968
Institutional Diet Study, *PHS*	July–September 1968	April 1969
Tri-City Diet, *HASL*	January–June 1968	April 1969

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Last presented
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Drinking Water Analysis Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
Minnesota	January–June 1968	February 1969
New York	January–June 1968	April 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	January–June 1968	April 1969
Washington	July 1966–June 1967	June 1969

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States January 1969

Division of Pollution Surveillance
Federal WaterPollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports*.

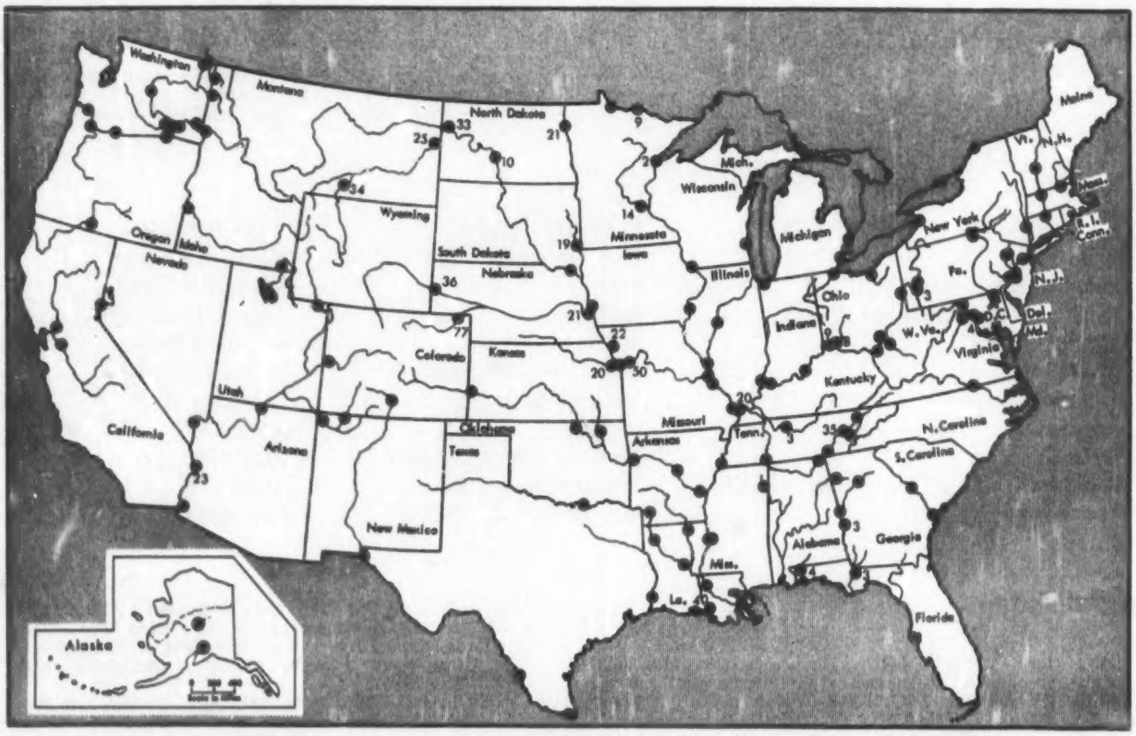
Washington
Montana
North Dakota
33
25
21
9
10
2
Mich.
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
34
Wyoming
Wisconsin
14
Michigan
New York
Oregon
Idaho
Nevada
South Dakota
19
Minnesota
Iowa
Nebraska
36
Illinois
Pa.
N.J.
3
Ohio
D.C.
Del.
Md.
21
22
77
Colorado
Kansas
Indiana
9
W. Va.
4
Virginia
20
30
Kentucky
Utah
20
California
Arizona
Oklahoma
Missouri
Arkansas
Tenn.
3
35
N. Carolina
S. Carolina
Texas
23
New Mexico
Alabama
3
Georgia
Miss.
La.
Florida
Alaska

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, January 1969

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations in the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During January 1969, the following stations showed alpha radioactivity values in excess of 15 pCi/liter for either suspended or dissolved solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

Also, during January 1969, no station showed beta radioactivity values in excess of 150 pCi/liter.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

Table 1. Radioactivity in raw surface waters, January 1969

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Apalachicola River:						
Chattahoochee, Fla	0	0	0	1	2	3
Atchafalaya River:						
Morgan City, La	8	0	8	34	6	40
Big Horn River:						
Hardin, Mont	1	2	3	10	24	34
Big Sioux River:						
Sioux Falls, S. Dak	0	3	3	<1	19	19
Chattahoochee River:						
Columbus, Ga	0	0	0	1	2	3
Clinch River:						
Kingston, Tenn[a]	0	0	0	2	33	35
Colorado River:						
Parker Dam, Calif-Ariz	0	6	6	1	22	23
Cumberland River:						
Cheatham Lock, Tenn	0	0	0	0	3	3
Escambia River:						
Century, Fla	0	0	0	1	3	4
Great Lakes:						
Duluth, Minn	0	0	0	0	2	2
Kansas River:						
DeSoto, Kans	1	2	3	4	16	20
Little Miami River:						
Cincinnati, Ohio	0	1	1	1	7	8
Mississippi River:						
St. Paul, Minn	0	2	2	1	13	14
Missouri River:						
Williston, N. Dak	4	4	8	20	13	33
Bismark, N. Dak	<1	3	3	1	9	10
St. Joseph, Mo	1	4	5	2	20	22
Missouri City, Mo	9	4	13	31	19	50
Monongahela River:						
Pittsburgh, Pa	0	0	0	0	3	3
North Platte River:						
Henry, Nebr	1	28	29	5	31	36
Ohio River:						
Cincinnati, Ohio	1	0	1	1	8	9
Cairo, Ill	3	0	3	13	7	20
Platte River:						
Plattsmouth, Nebr	0	5	5	2	19	21
Potomac River:						
Washington, D. C	0	0	0	1	3	4
Rainy River:						
International Falls, Minn	0	0	0	1	8	9
Red River, North:						
Grand Forks, N. Dak	0	0	0	3	18	21
South Platte River:						
Julesburg, Colo	4	34	38	14	63	77
Yellowstone River:						
Sidney, Mont	0	5	5	2	23	25
Maximum	9	34	38	34	63	77
Minimum	0	0	0	0	2	2

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

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1. Radiation Alert Network
April 1969

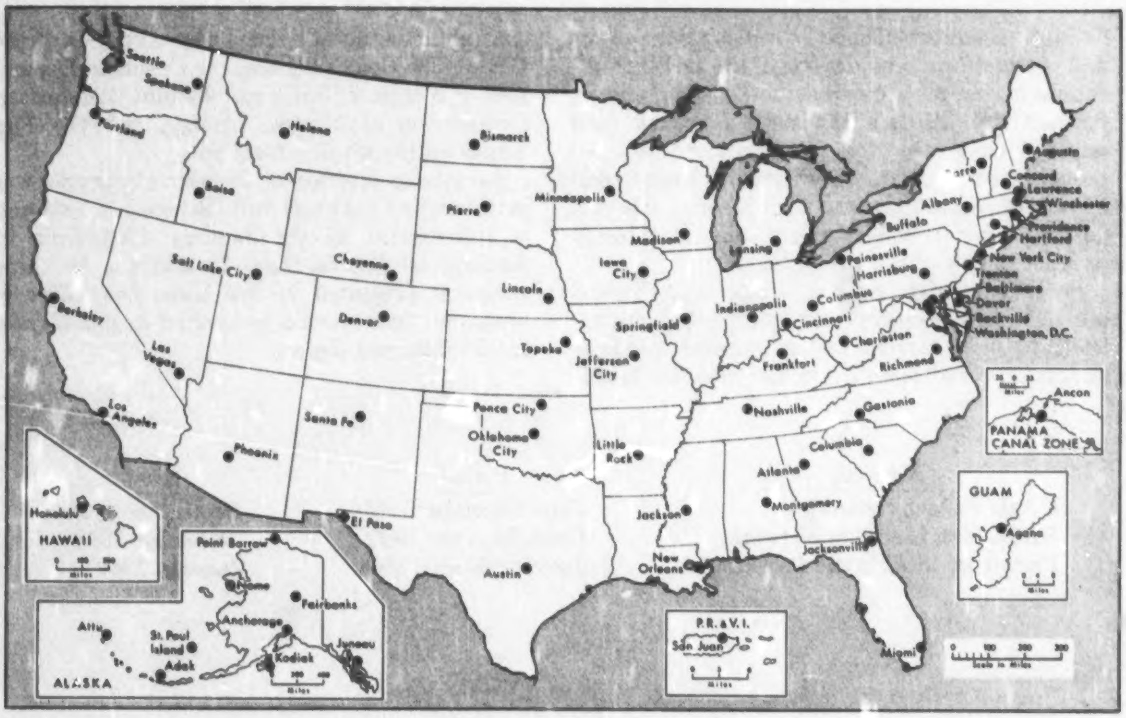
Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during April 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.



Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Cheyenne
Salt Lake City
Lincoln
Iowa City
Denver
Berkeley
Topeka
Springfield
Indianapolis
Columbus
Cincinnati
Charleston
Jefferson City
Frankfort
Richmond
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Little Rock
Nashville
Gastonia
Phoenix
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
Albany
Buffalo
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Ancon
PANAMA CANAL ZONE
GUAM
Agana
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
ALASKA
P.R. & V.I.
San Juan
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, April 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	5	0	2	Feb 69	5	83	5	83	23
Alaska:	Adak	4	2	1	1	Feb 69	(c)				
	Anchorage	3	0	0	0	Oct 68	(c)				
	Attu Island	15	0	0	0	Mar 69	(c)				
	Fairbanks	(b)				Nov 68	(c)				
	Juneau	21	0	0	0	Dec 68	15	148	13	122	0
	Kodiak	2	0	0	0	Jan 69	(c)				
	Nome	(b)			0	May 69	(c)				
	Point Barrow	30	0	0	0	Apr 69	(c)				
	St. Paul Island	16	1	1	1	June 69	(c)				
Ariz:	Phoenix	21	10	2	5	Dec 68	(c)				
Ark:	Little Rock	9	2	0	1	Aug 69	(c)				
Calif:	Berkeley	22	1	0	0	Jan 69	6	64	6	64	0
	Los Angeles	22	2	0	0	May 69	(c)				
C.Z:	Ancon	16	0	0	0	Jan 69	(c)				
Colo:	Denver	20	8	0	2	Jan 69	2	10	(d)		
Conn:	Hartford	20	0	0	0	Nov 68	9	73	9	73	0
Del:	Dover	21	2	0	0	July 69	(c)				
D.C.:	Washington	4	2	0	1	Apr 69	(c)				
Fla:	Jacksonville	22	1	0	0	Aug 69	5	110	4	105	93
	Miami	17	0	0	0	Nov 68	7	102	7	102	0
Ga:	Atlanta	22	2	1	1	June 69	2	57	2	57	40
Guam:	Agana	(b)				July 69	(c)				
Hawaii:	Honolulu	26	1	0	0	Mar 69	2	30	(d)		
Idaho:	Boise	20	3	1	2	Mar 69	4	46	3	40	6
Ill:	Springfield	23	3	0	2	Apr 69	3	70	0	0	(e)
Ind:	Indianapolis	21	2	0	1	June 69	8	118	8	118	133
Iowa:	Iowa City	20	3	0	1	Jan 69	5	104	5	104	0
Kans:	Topeka	19	3	0	1	Aug 69	6	119	6	119	2
Ky:	Frankfort	5	1	1	1	Apr 69	(c)				
La:	New Orleans	19	2	0	0	Apr 69	8	147	(d)		
Maine:	Augusta	21	1	0	0	May 69	9	109	9	100	0
Md:	Baltimore	21	2	0	1	Nov 68	6	53	6	53	31
	Rockville	12	1	0	0	Mar 69	(c)				
Mass:	Lawrence	19	2	0	0	July 69	6	87	6	87	2
	Winchester	22	2	0	0	Feb 69	8	98	8	98	0
Mich:	Lansing	22	3	1	2	Mar 69	9	64	9	64	117
Minn:	Minneapolis	20	1	0	0	July 69	4	48	4	48	5
Miss:	Jackson	16	1	0	0	May 69	4	243	4	243	41
Mo:	Jefferson City	21	2	0	0	June 69	8	103	8	103	0
Mont:	Helena	21	9	0	3	Feb 69	4	4	4	4	3
Nebr:	Lincoln	19	4	1	2	June 69	3	91	3	91	54
Nev:	Las Vegas	17	3	0	1	Nov 68	(c)				
N.H.:	Concord	20	2	0	0	Apr 69	(c)				
N.J:	Trenton	21	2	0	1	May 69	(c)				
N. Mex:	Santa Fe	11	2	0	1	Feb 69	3	43	1	21	0
N.Y:	Albany	18	1	0	1	June 69	8	59	8	50	50
	Buffalo	22	1	0	0	Jan 69	(c)				
	New York City	19	0	0	0	Feb 69	(c)				
N.C:	Gastonia	16	8	1	3	Jan 69	5	78	(d)		
N. Dak:	Bismarck	21	3	0	1	Apr 69	2	24	2	24	0
Ohio:	Cincinnati	(b)				July 69	(c)				
	Columbus	18	2	0	1	May 69	8	92	1	34	0
	Painesville	20	1	0	1	Nov 68	14	97	14	97	28
Okla:	Oklahoma City	18	2	0	1	Mar 69	3	34	3	34	0
	Ponca City	21	5	0	1	Nov 68	7	62	7	62	6
Ore:	Portland	51	2	0	1	June 69	13	75	13	75	4
Pa:	Harrisburg	6	1	0	1	June 69	(c)				
P.R:	San Juan	(b)				May 69	(c)				
R.I:	Providence	23	1	0	0	Mar 69	(c)				
S.C:	Columbia	20	2	0	0	Feb 69	5	106	5	106	25
S. Dak:	Pierre	13	6	1	3	Dec 68	(c)				
Tenn:	Nashville	(b)				Mar 69	(c)				
Tex:	Austin	19	5	0	3	July 69	6	87	(d)		
	El Paso	(b)				Apr 69	(c)				
Utah:	Salt Lake City	32	2	0	1	May 69	5	30	5	30	4
Vt:	Barre	20	2	0	1	Aug 69	9	63	9	63	0
Va:	Richmond	21	0	0	0	Aug 69	7	94	7	94	18
Wash:	Seattle	15	0	0	0	Aug 69	7	55	(d)		
	Spokane	22	2	0	1	July 69	(c)				
W. Va:	Charleston	23	2	0	1	Feb 69	12	69	12	69	18
Wisc:	Madison	23	1	0	0	Aug 69	9	81	9	81	50
Wyo:	Cheyenne	21	7	0	3	Nov 68	3	22	3	22	21
Network summary		1,219	10	0	1		6	78	6	77	21

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

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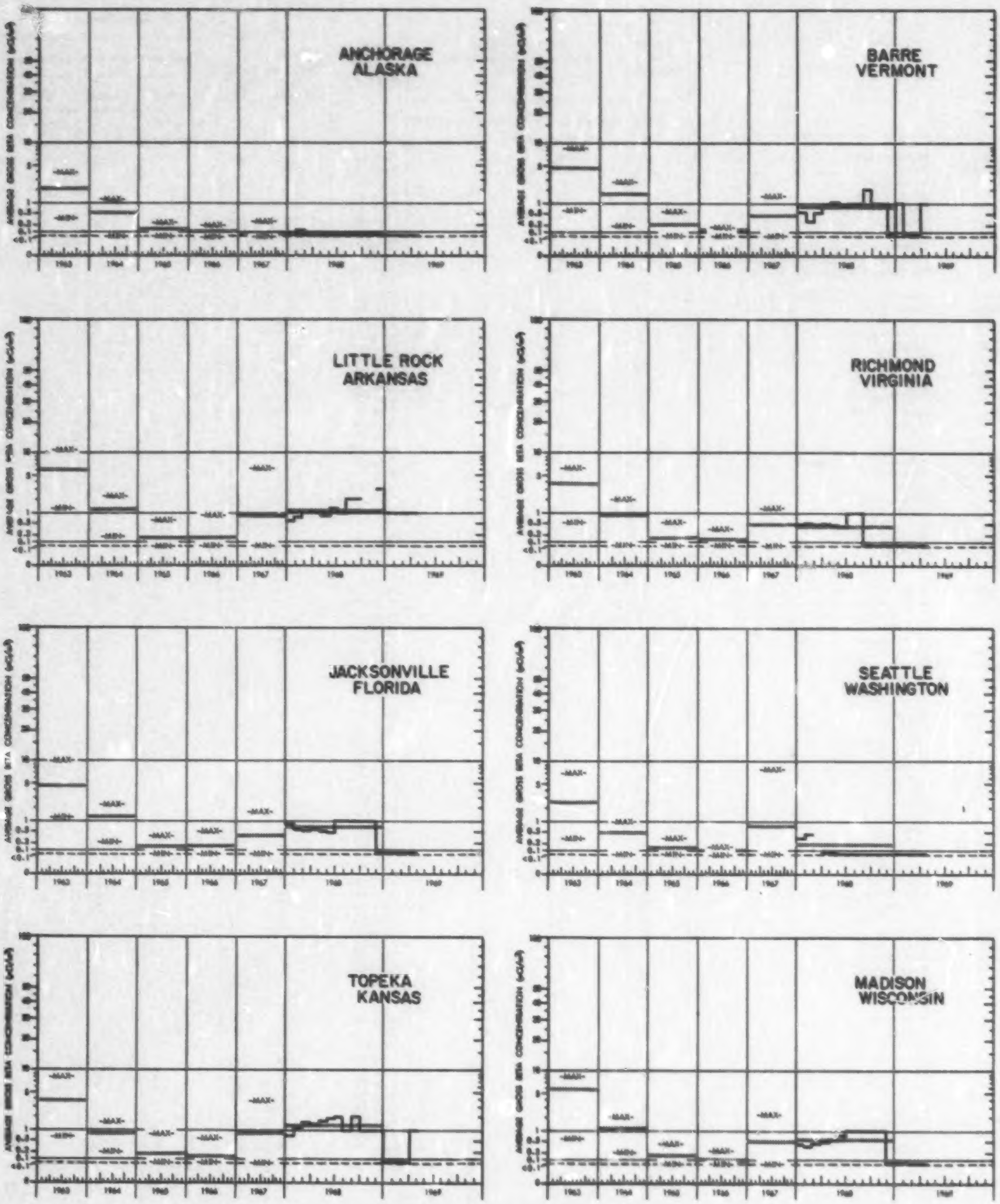

Figure 2. Monthly and yearly profiles of beta radioactivity in air, Radiation Alert Network, 1963–April 1969

2. Canadian Air and Precipitation Monitoring Program[1], April 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the July 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for April 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, April 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.3	0.0	0.1	34	1.9
Coral Harbour	29	.2	.0	.1	65	.2
Edmonton	30	.3	.0	.1	156	3.6
Ft. Churchill	29	.2	.0	.1	28	.8
Ft. William	10	.2	.1	.1	126	4.4
Fredericton	29	.2	.0	.1	40	3.0
Goose Bay	30	.1	.0	.1	31	1.2
Halifax	30	.2	.0	.1	50	4.9
Inuvik	30	.1	.0	.1	150	.7
Montreal	30	.2	.1	.1	53	5.2
Moosonee	30	.3	.0	.1	36	.5
Ottawa	30	.3	.0	.1	58	7.1
Quebec	30	.2	.0	.1	53	5.0
Regina	30	.2	.0	.1	87	1.9
Resolute	28	.2	.1	.1	71	.3
St. John's, Nfld	29	.2	.0	.1	27	2.9
Saskatoon	30	.2	.1	.1	228	2.4
Saulte Ste Marie	30	.2	.0	.1	54	5.0
Toronto	30	.2	.0	.1	66	4.7
Vancouver	30	.2	.0	.1	60	6.3
Whitehorse	30	.1	.0	.0	80	.3
Windsor	28	.2	.0	.1	69	6.7
Winnipeg	30	.3	.0	.1	112	2.8
Yellowknife	30	.1	.0	.1	19	.4
Network summary	692	0.3	0.0	0.1	73	3.0

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[1] Prepared from information and data in the may 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

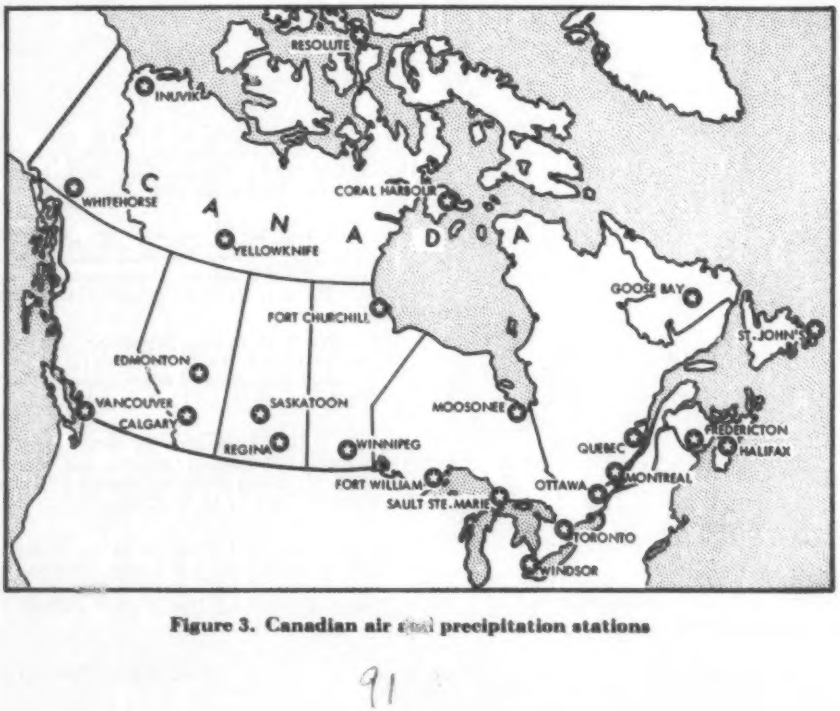
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation stations

3. Pan American Air Sampling Program April 1969

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. It should be noted that a new sampling station has been established in Cuenca, Ecuador. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The April 1969 air monitoring results from the participating countries are given in table 3.

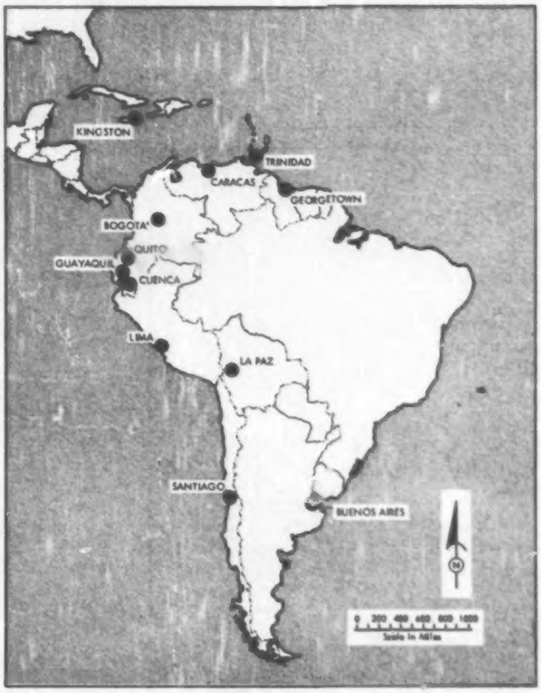

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, April 1969

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	15	0.43	0.12	0.31
Bolivia: La Paz	15	.57	.07	.21
Chile: Santiago	30	.62	.36	.50
Colombia: Bogota	17	.48	.16	.30
Ecuador: Cuenca	4	.24	.22	.23
Guayaquil	17	.36	.02	.22
Quito	18	.23	.17	.22
Guyana: Georgetown	16	.89	.03	.59
Jamaica: Kingston	18	.49	.06	.25
Peru: Lima	NS			
Venezuela: Caracas	18	1.32	.07	.36
West Indies: Trinidad	17	.32	.14	.21
Pan American summary	185	1.32	0.02	0.33

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no sample.

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(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Feed Materials Production Center, and the National Reactor Testing Station.

---

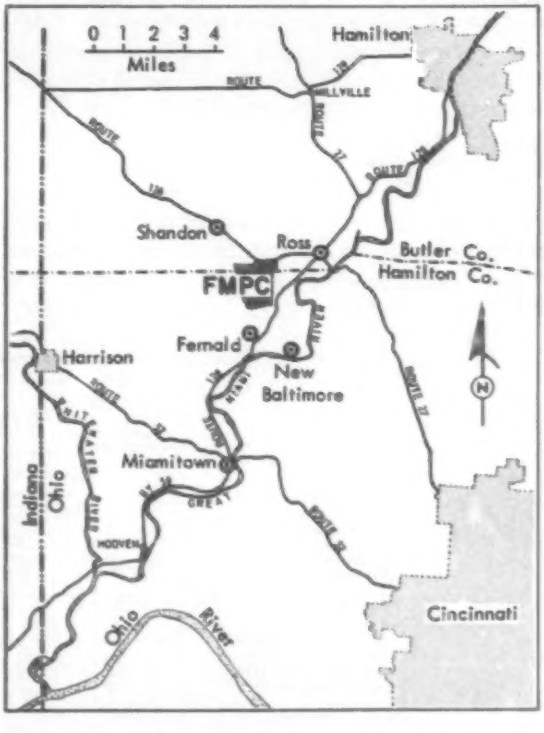
[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Feed Materials Production Center[2]
July-December 1968

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal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Ohio River
Cincinnati

Figure 1. Area map of Feed Materials Production Center

of the materials is accomplished by using dust collectors and waste treatment processes. In order to determine what concentrations reach the area surrounding the project an environmental survey program has been established which consists of water, soil, and air sampling of the environs and performing those analyses on the samples that are indicative of material released from the plants.

---

[2] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the Second Half of 1968, Summary Report for 1968" (NLCO-1030).

Air monitoring

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 2. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 1.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants are collected at a general sump for equalization and settling. The clear water from the sump is pumped to the river The solid portion is pumped to a chemical waste pit for further settling. The flow, which is decanted to the clear well portion of the pit, is virtually free of solids and radioactivity. The effluent from the sump and clear well are combined with waste water from the FMPC water treatment plant, sanitary sewage treatment plant, and storm sewage system and discharged via a common effluent outfall into the Great Miami River. A Parshal-Flume-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contami-

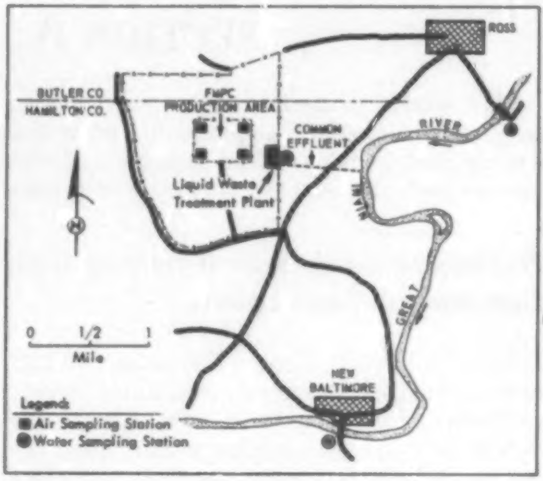

Figure 2. Air and water sampling stations, Feed Materials Production Center

Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, July–December 1968

Location	Number of samples	Uranium concentration (pCi/m³)[a]			Total radioactivity (pCi/m³)[b]		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest	5	0.1	<0.1	<0.1	0.2	<0.1	0.1
Northwest	26	1.0	< .1	.1	2.1	< .1	.3
Northeast	26	.5	< .1	.2	.9	.1	.4
Southeast	26	1.0	< .1	.2	1.9	< .1	.4
All onsite samples	83			.2			.4
Offsite:							
0–2 miles from FMPC	26	.3	< .1	< .1	.8	< .1	.2
2–4 miles from FMPC	22	.2	< .1	< .1	.5	< .1	.2
4–8 miles from FMPC	33	.4	< .1	< .1	.6	< .1	.1
8–12 miles from FMPC	16	[illegible]	< .1	< .1	.3	< .1	.2
All offsite samples	107			.1			.2

[a] AEC radiation protection standard—2 pCi/m³.
[b] AEC radiation protection standard—100 pCi/m³.

nant concentrations added to the river. Weekly spot samples are also obtained upstream and downstream; a continuous sample is taken for a 24-hour period and random samples are analyzed each week. The results of the FMPC water monitoring program for July–December 1968 are summarized in table 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	August 1968
January–June 1968	April 1969

Table 2. Radioactivity in the Great Miami River, Feed Materials Production Center July–December 1968

Location	Number of samples	Uranium concentration (pCi/liter)[a]			Total radioactivity (pCi/liter)[b]		
		High	Low	Average	High	Low	Average
Sewer outfall	184	20	<10	<10	70	<10	10
Upstream from outfall	21	10	<10	7	60	<10	20
Downstream from outfall	25	50	<10	10	90	10	30

[a] AEC radiation protection standard—20,000 pCi/liter.
[b] AEC radiation protection standard— 3,000 pCi/liter.

2. National Reactor Testing Station[3] January-June 1968

Health Services Laboratory
U.S. Atomic Energy Commission
Idaho Falls, Idaho

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during the first half of 1968 did not contribute significantly to environmental radiation or radioactivity concentration levels. These levels remained well below the levels defined as thresholds of concern by the Federal Radiation Council (FRC). The radiation protection standards used at the NRTS, which are established in AEC Manual Chapter 0524, are based on FRC recommendations. In choosing applicable standards for drinking water, credit has been taken for the fact that no significant quantities of radium-226 or radium-228 have been released to the environs by NRTS operations. The concentrations of radioactivity reported include contributions from all sources. No attempt has been made to separate radioactivity contributed by NRTS operations from that contributed by natural sources of radioactivity or by fallout from weapons debris. Samples of air, water and milk are collected routinely at stations shown in figure 3. The results of the analyses performed on the air, water, and milk samples are shown in table 3.

Water monitoring

Low-level liquid wastes from various operating facilities at the NRTS are released to the groundwater table through disposal wells and ponds located near each facility. Before disposal the liquid wastes are carefully monitored at the NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly from those populated areas nearest the site boundaries. Samples from these locations, as shown on the accompanying map, plus the onsite samples provide adequate information on the underground water leaving the NRTS. A total of 12 offsite underground water samples and two surface water samples were collected during this report period.

Onsite samples are collected on a biweekly basis and offsite samples semiannually. A total of 218 water samples were collected onsite for the first 6 months of 1968.

Air monitoring

The filters from onsite continuously operated samplers are collected and analyzed weekly. These filters are analyzed for gross alpha, gross beta, and iodine-131 radioactivity. A sampler with filters identical to those used for onsite monitoring is located at Idaho Falls which indicates the radioactivity level from only natural and nuclear weapon fallout material. The onsite and Idaho Falls air monitoring stations are shown in figure 3. The monitoring results from Idaho Falls are listed in tables 3 as the offsite station.

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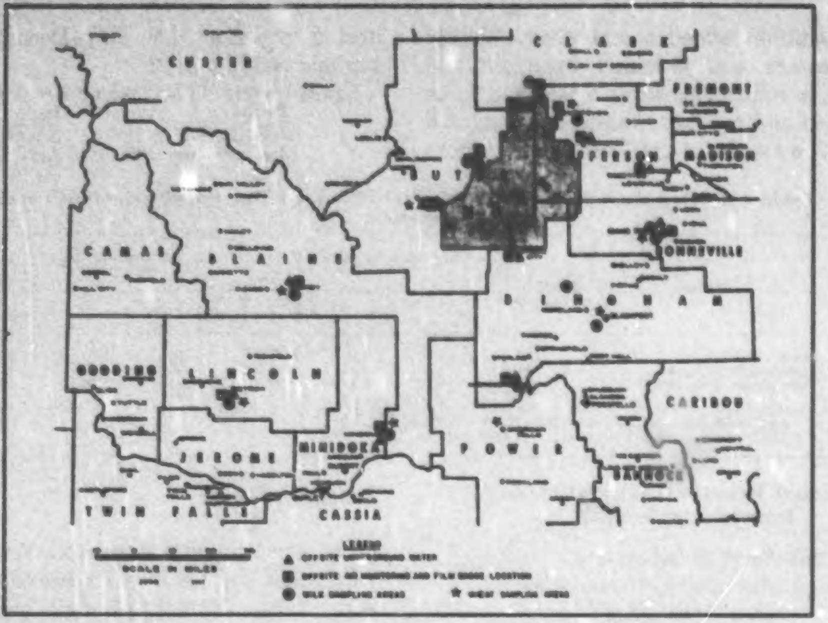
[3] Summarized from "Environmental Monitoring Report No. 22, January–June 1968," U.S. Atomic Energy Commission, Idaho Operations Office, Health Services Laboratory, National Reactor Testing Station.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SCALE IN MILES
LEGEND
OFFSITE UNDERGROUND WATER
OFFSITE AIR MONITORING AND FILM BADGE LOCATION
MILK SAMPLING AREAS
WHEAT SAMPLING AREAS

Figure 3. Environmental monitoring stations, National Reactor Testing Station

Offsite milk monitoring

Offsite milk samples are collected routinely and analyzed for iodine-131 and strontium-90 radioactivity. During the first 6 months of 1968 a total of 90 milk samples were analyzed. The milk sample results are given in table 3.

Gamma radiation levels

Semiannual measurements (table 3) of external gamma radiation levels were made with thermoluminescent dosimeters (TLD) at 11 offsite locations during January-June 1968.

Natural background radiation levels at TLD locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100-150 mR/yr. This indicates that NRTS operations have added no significant radiation to surrounding areas.

Recent coverage in *Radiological Health Data and Reports.*

Period	Issue
January-June 1967	March 1968
Calendar year 1967	October 1968

Table 3. Environmental monitoring data for the National Reactor Testing Station, January-June 1968

Type of sample and units	January-June 1968						
	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	AEC standards
Onsite production well water, (pCi/liter)	22	Biweekly	Alpha	3	9	<3	3,000
			Beta	5	36	<6	3,000
Offsite underground water, (pCi/liter)	12	Semiannual	Alpha	3	4	4	100
			Beta	5	<5	<5	100
Surface water, (pCi/liter)	2	Semiannual	Alpha	3	4	4	100
			Beta	5	<5	<5	100
Onsite air, (pCi/m³)	8	Continuous	Alpha	0.001	0.005	0.002	1
			Beta	.003	3.17	.05	300
			Iodine-131	.09	5.16	.13	9,000
Offsite air, (pCi/m³)	1	Continuous	Alpha	.001	.007	.002	0.04
			Beta	.003	1.40	.05	10
			Iodine-131	.09	.16	.02	100
Offsite milk, (pCi/liter)	12	Monthly	Iodine-131	20	20	20	100
			Strontium-90	1	10	<6	200
Offsite area monitoring badges, (mR)	11	Semiannual	Gamma	10	145	48	170/yr

Reported Nuclear Detonations, July 1969

The U.S. Atomic Energy Commission announced that two nuclear tests of low-intermediate yield (20-200 kilotons TNT equivalent) were conducted underground on July 16, 1969 by the Atomic Energy Commission at its Nevada Test Site.

On July 22, 1969, the United States recorded seismic signals which originated from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20-200 kilotons TNT equivalent).

Erratum

In the report "Preliminary Results of Surveys of 5,263 Medical X-ray Facilities, 1962–1967" by the Bureau of Radiological Health, which appeared in the June 1969 issue of *Radiological Health Data and Reports*, the sixth line in the first paragraph on page 235 should be corrected to read ". . . 1962 to 1967. Seven States, 1 territory and the. . . .".

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ENVIRONMENTAL SURVEILLANCE AROUND A NUCLEAR FUEL REPROCESSING INSTALLATION, 1965–1967. *William J. Kelleher. Radiological Health Data and Reports, Vol. 10, August 1969*, pp. 329-339

A summary report of environmental surveillance around a nuclear fuel reprocessing plant is presented. This report includes data obtained before and after the plant began operations in April 1966. Media monitored included air and milk supplies in the surrounding area; liquid wastes; local watersheds and streams; silt, deer, and fish in the plant perimeter area. Data obtained through 1967 indicate that the discharges from the plant stack have not produced environmental effects from particulate beta-particle emitters or iodine-131 that might constitute a public health hazard. Surveillance of the streams showed greater concentration of strontium-90 during the fall and winter of 1966–1967 than in the latter part of 1967. Silt removed more cesium-137 than strontium-90; most of the latter was in the dissolved state. The ratio of cesium-137 to cesium-134 (cesium-134 is indicative of spent fuel) in the wastes was about 4 or 5 to 1. The levels of radioactivity in deer and fish were sufficiently high to require careful evaluation of the public health significance.

KEYWORDS: Air, cesium-134, cesium-137, deer, environmental surveillance, fish, iodine-131, milk, New York State, nuclear fuel reprocessing plant, radioactivity, silt, strontium-90, water.

A 5-YEAR SUMMARY OF THE REGULATORY CONTROL OF RADIOACTIVE MATERIAL IN ARKANSAS. *E. F. Wilson and D. D. Snellings, Jr. Radiological Health Data and Reports, Vol. 10, August 1969*, pp. 341-345.

The Arkansas State Department of Health, Division of Radiological Health, in assuming the regulatory control of radioactive material on July 1, 1963, instituted a program of licensing and inspection of all users of regulated material with the ultimate goal of preventing, if possible, or reducing to an acceptable level, the exposure of ionizing radiation.

This report is a summary of regulatory activities of the Division of Radiological Health from 1964 through and including 1968. The early (1964) regulatory inspections did not include sufficient data pertaining to the occupational exposure of individuals to radiation; however, the noted deficiencies of records and radiation safety are well documented. In early 1967, the Division of Radiological Health prepared all previous data for electronic data processing, and currently all regulatory inspections, as well as licensing activities, are prepared for electronic data processing on a routine basis.

KEYWORDS: Arkansas, compliance, ionizing radiation, licenses, occupational exposure, radium.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 9, September 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration ● Bureau of Radiological Health

Technical Notes

Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1968

M. E. Miles and *J. J. Mangeno*[1]

This report summarizes data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm the adequacy of waste disposal limits and procedures. The waste disposal data show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships totaled 0.10 curie in 1968 for all harbors. This is comparable to 0.39 curie in 1966 and 0.11 curie in 1967 for all harbors, and is less than the average of 4 curies reported discharged per year during 1961 through 1965. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt-60 have shown that, (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase over the general background radioactivity of the environment, and (3) low-level cobalt-60 radioactivity is detectable in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships have been conducted over a period of several years.

This report confirms that procedures used by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public.

A detailed description of the means of disposing of radioactive wastes and the sources of these wastes has been presented earlier (*1*). Table 1, which updates information in previous reports (*1–3*), lists the total amount of long-lived radioactivity discharged as liquid wastes into various harbors during the past 5 years. Solid radioactive materials from ships are transferred to a shipyard or other shore facility for packaging and disposal. For ultimate disposal, solid radioactive wastes are shipped to Atomic Energy Commission or State-approved burial sites since shipyards and shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. The total radioactivity and volumes of solid radioactive wastes disposed of from 1964 through 1968 are shown in table 2.

Environmental monitoring survey procedures have been described in a previous report (*1*). A summary of the 1968 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled, or built is present in table 3.

Once each quarter, a total of at least five water samples is taken at various locations in each harbor in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross radioactivity and for cobalt-60. No harbor water sample has shown detectable cobalt-60 radioactivity. No increases in gross radioactivity of harbor water have been detected.

Monitoring for cobalt-60 in harbor bottom sediment is conducted each quarter year by collecting 20 to 100 samples with a 6-inch square sampler. Samples are taken of the top one-half to

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[1] Nuclear Power Directorate, Naval Ship Systems Command, Department of the Navy.

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Table 1. Radioactive liquid waste discharges to harbors from U.S. Naval nuclear-powered ships and their support facilities for 1964 through 1968[a]

Location[b]	1964		1965		1966		1967		1968	
	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies
Portsmouth, N.H; Naval Shipyard	407	0.13	204	0.24	155	0.01	265	0.01	171	0.01
Quincy, Mass; Quincy Division		[c] ND		ND		ND		ND		ND
Groton-New London, Conn; Electric Boat Div., State Pier and Submarine base	201	1.93	828	1.29	1,274	.03	606	.01	460	.01
Newport News, Va; Newport News Shipbuilding	965	.24	3,360	1.70	1,561	.06	1,533	.04	1,146	.03
Norfolk, Va; Naval Shipyard and base	337	.61	1,146	.44	1,051	.03	1,784	.03		ND
Charleston, S.C; Naval Shipyard and base	294	.36	717	.67	389	.04	320	.01		ND
Pascagoula, Miss; Ingalls Shipbuilding Division		ND		ND		ND		ND		ND
San Diego, Calif; Navy Pier at Ballast Point	35	.40	40	.33		ND		ND		ND
Long Beach, Calif; Naval Shipyard and base		ND		ND		ND		ND		ND
Vallejo, Calif; San Francisco Bay Naval Shipyard	63	.62	126	.21	270	.19		ND	391	.03
Bremerton, Wash; Puget Sound Naval Shipyard		ND	198	.01		ND		ND		ND
Pearl Harbor, Hawaii; Naval Shipyard and base	405	.98	548	.48	654	.03	683	.01	886	.01
Apra Harbor, Guam		ND	69	.01		ND		ND		ND
Total	2,707	5.27	7,236	5.38	5,354	0.39	5,191	0.11	3,063	[d] 0.10

[a] Radioactivity data are reported as if the entire radioactivity consisted of cobalt-60. Volumes are reported prior to dilution.

[b] All other harbors in the U.S. and the rest of the world received a total discharge of 0.013 curies in 1966, 0.001 curies in 1967 and less than 0.001 curies in 1968.

[c] Where discharges in a harbor for a year totaled less than 0.005 curies, ND is reported.

[d] Total of 0.10 curies for 1968 includes discharges reported as ND in this column.

one inch of sediment in the immediate vicinity of and away from berthing areas used by the Naval nuclear-powered ships. These surveys show that the total amount of cobalt-60 observed in bottom sediment near a few piers is small compared to natural radioactivity present in harbors.

Samples from each of these harbors are also checked at least annually by a U.S. Atomic Energy Commission (AEC) laboratory to ensure that analytical procedures are correct and standardized. In addition, the U.S. Navy cooperates with the U.S. Public Health Service (PHS), surveys in some U.S. harbors. Results reported in table 3 are consistent with these AEC and PHS checks.

Twice per year shoreline areas uncovered at low tide are surveyed for radiation levels with sensitive radiation detectors to determine if any

Table 2. Radioactive solid waste disposed of by facilities supporting U.S. Naval nuclear-powered ships for 1964 through 1968[a]

Location	1964		1965		1966		1967		1968	
	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies
Portsmouth, N.H; Naval Shipyard	80	2.6	150	2.6	194	9.5	300	198.1	314	150.7
Quincy Mass; Electric Boat Division		[b] ND		ND		ND		ND		ND
Groton-New London, Conn.; Electric Boat Div., Tender at State Pier and Submarine base	99	2.3	155	353.0	148	1,092.8	46	17.0	44	20.7
Newport News, Va; Newport News Shipbuilding	22	1.8	198	28.0	70	8.9	167	701.9	144	10.2
Norfolk, Va; Naval Shipyard and tender	5	.5	33	1.6	43	2.5	108	85.6	23	11.2
Charleston, S.C.; Naval Shipyard and tenders	47	1.0	78	111.5	77	5.6	151	52.0	136	109.9
Pascagoula, Miss; Ingalls Shipbuilding Division		ND		ND		ND		ND		ND
San Diego, Calif; Tenders at Ballast Point	7	7.5	3	ND	6	.1	7	.2	14	7.6
Long Beach, Calif; Naval Shipyard and base		ND		ND		ND		ND		ND
Vallejo, Calif. San Francisco Bay Naval Shipyard	9	.3	47	9.4	90	367.0	92	22.8	76	6.6
Bremerton, Wash; Puget Sound Naval Shipyard		ND	4	.1	14	.5	141	192.8	130	48.2
Pearl Harbor, Hawaii; Naval Shipyard and base	13	.7	8	1.4	7	.3	11	1.0	32	5.5
Total	282	16.7	676	507.6	649	1,487.2	1,023	1,271.4	922	370.6

[a] This table includes waste from tenders and nuclear-powered ships since such waste is transferred to support facilities for disposal.

[b] Where total radioactivity is less than 0.05 curies, ND is reported in this table.

Table 3. Summary of 1968 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled, or built

Location	Number of samples with cobalt-60 concentration of: [a]			Total bottom area with cobalt-60 over 10 pCi/cm² (km²)	Estimated total cobalt-60 in top layer of sediment [b] (Ci)
	<10 pCi/cm²	10-100 pCi/cm²	> 100 pCi/cm²		
Portsmouth, N.H. Naval Shipyard	180	0	0	0	ND
Quincy, Mass. Quincy Division	48	0	0	0	ND
Groton-New London, Conn., Electric Boat Div., State Pier, and Submarine base	189	106	23	0.3	0.1
Newport News, Va. Newport News Shipbuilding	150	1	0	.001	ND
Norfolk, Va., Naval Shipyard and base	336	0	0	0	ND
Charleston, S.C., Naval Shipyard and base	384	0	0	0	ND
Pascagoula, Miss., Ingalls Shipbuilding Division	84	0	0	0	ND
San Diego, Calif., Navy Pier at Ballast Point	168	0	0	0	ND
Long Beach, Calif., Naval Shipyard and base	160	0	0	0	ND
Vallejo, Calif., San Francisco Bay Naval Shipyard	443	0	0	0	ND
Bremerton, Wash., Puget Sound Naval Shipyard	140	0	0	0	ND
Pearl Harbor, Hawaii, Naval Shipyard and base	244	43	1	.2	.02
Apra Harbor, Guam	107	0	0	0	ND

[a] Minimum detectable radioactivity is approximately 2 pCi/cm². Results in units of pCi/g are approximately half the value in pCi/cm².

[b] Total is from areas with cobalt-60 over 10 pCi/cm², which were in the immediate vicinity of piers used for berthing nuclear-powered ships. Where total cobalt-60 is less than 0.01 curie, ND is reported. Core samples more than 1-foot deep from several harbors show that total cobalt-60 present may be two to five times that measured in the surface layer.

radioactivity from bottom sediment washed ashore. All results were in the range of 0.01 to 0.04 millirem per hour, the same as background radiation levels in similar areas. Thus, there is no evidence in these ports that radioactivity from sediment is washing ashore.

Throughout the year film badges are posted at locations outside the boundaries of areas where radioactive work is performed. These films showed that radiation exposure to the general public outside these facilities was not above that received from natural background radiation levels.

In addition to the locations listed in table 3, environmental monitoring has been accomplished by the U.S. Navy submarine tenders which serve as operating bases for U.S. Naval nuclear-powered submarines in Rota, Spain, and Holy Loch, Scotland. Results of the surveys in the harbor at Rota, Spain, have not shown detectable cobalt-60 in harbor bottom sediment samples. In 1965, in Holy Loch, more cobalt-60 radioactivity than expected was detected in harbor bottom sediment and on shoreline mud flat areas uncovered at low tide. However, there had been no increase of harbor water radioactivity in Holy Loch above normal background levels. Joint U.S. and British assessments of survey results confirmed that radiation levels in the vicinity of the Holy Loch anchorage were far below those which were at all likely to cause an individual to receive a radiation exposure approaching the limits for members of the general public. Environmental monitoring during 1968 showed that radioactivity levels in Holy Loch are steadily declining.

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Summary of Diagnostic X-Ray Statistics Relating Facilities, Equipment, and Personnel by Healing Arts Professions[1]

Lawrence R. Fess[2]

The potential hazard of x-ray emissions from electronic products has been subjected to increasing scrutiny by health agencies and the general public. The need exists for information concerning all sources of exposure to such radiation, including medical and dental x radiation. One area of the problem pursued by the Bureau of Radiological Health is the compilation of information relating to diagnostic x-ray equipment and the operators of such equipment.

Data have been derived, based primarily on the collection of Radiation Protection Survey Reports from States, which provide estimates of the numbers of x-ray machines and of machine operators and practitioners who are involved with the use of x rays in various types of practice.

Table 1 has been constructed to summarize the available statistics on personnel, facilities, and equipment in the field of diagnostic x ray. These provide estimates of the number of practitioners, machines, facilities, operators, and personnel who may be occupationally exposed. As is evident from the footnotes, few of the figures have a simple or direct source, such as a complete count.

To summarize the table briefly, there are an estimated 387,000 non-federal practitioners in the healing arts professions who are directly or indirectly associated with the operation of approximately 207,000 diagnostic x-ray machines. One hundred and twelve thousand of these machines, classified as medical units, are located in approximately 78,000 x-ray facilities that employ 161,000 x-ray machine operators and an additional 34,000 persons who are classified as occupationally exposed personnel. In these medical facilities, an estimated 67,000 persons or about one-third of the occupationally exposed are equipped with personnel monitoring devices. Ninety-four thousand machines located in 86,000 facilities are classified as dental diagnostic type machines. These facilities have approximately 150,000 x-ray machine operators and an additional 21,000 individuals who may be considered as being occupationally exposed. In the dental facilities, an estimated 8,600 persons or 5 percent of the occupationally exposed are equipped with personnel radiation monitoring devices.

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[1] Extracted from Radiation Control for Health and Safety Act of 1967, Hearings before the Committee on Commerce, United States Senate, 90th Congress, 2nd session on S2067, S3211, H.R. 10790, Part 2 (May 6, 8, 9, 13, 15, 1968) p. 1051.

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Table 1. Estimated numbers of healing arts practitioners and related statistics on diagnostic x-ray facilities, equipment, and personnel by healing arts profession as of June 1965

Healing arts profession	Number of practitioners	Diagnostic x-ray machines			Estimated number of x-ray facilities	Diagnostic X-ray machine personnel					
						Operators		Occupationally exposed		Monitored	
		Average per practitioner[a]	Total per profession[b]	Average per x-ray facility		Average per x-ray facility	Total per profession	Average per x-ray facility	Total per profession	Average per x-ray facility	Total per profession
Physicians total	[c,d]240,212	0.36	86,476	[b]1.64	[e]52,604	[b]2.42	[f]127,334	[b]2.92	[g]153,686	[b]1.20	[h]63,189
Private practice	[c,d](179,641)	(.29)	(52,096)	[b](1.16)	[i](45,015)	[j](2.14)	[i](96,219)	[k](2.57)	[i](115,665)	[l](.74)	[i](33,516)
Hospitals[m]	(60,571)	[b](.57)	(34,380)	[n](4.53)	(7,589)	[o](4.10)	(31,115)	[o](5.01)	(38,021)	[o](3.91)	(29,673)
Osteopaths	[p]11,074	.44	4,872	[o]1.01	4,824	[o]1.49	7,188	[o]1.65	7,960	[o].10	482
Chiropractors and Naturopaths	[q]24,000	.50	12,000	1.00	12,000	[o]1.12	13,440	[o]1.18	14,160	[o].14	1,680
Veterinarians	[r]18,219	.30	5,466	[o]1.05	5,206	[o]1.75	9,110	[o]2.23	11,609	[o].16	833
Podiatrists	[s]7,600	.47	3,572	[t]1.00	3,572	[t]1.00	3,572	[t]2.00	7,144	[t].10	357
Dentists	[u]86,317	[b]1.09	[v]94,174	[t]1.10	85,613	[t]1.75	149,823	[t]2.00	171,226	[t].10	8,561
Total	387,422	—	206,560	—	163,819	—	310,823	—	365,785	—	75,102

[a] From adjustments to best information available primarily in the annual review of Radiological Health Programs, fiscal year 1966, and non-federal practitioners in the healing arts (a composite sheet). Sources: For physicians, AMA Directory Report Service, Volume 16, Supplement 76 (July 1964); for others, National Center for Health Statistics, Health Manpower Statistics Section, PHS, DHEW; and Pocket Data Book, The United States Bureau of the Census, U.S.A. (1967).

[b] Figures were calculated from associated figures presented within the table.

[c] HEALTH RESOURCES STATISTICS. Health Manpower, PHS Publication No. 1509. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1965).

[d] AMA Directory 17, Supplement 34 (October 4, 1965). This document provides a ratio of the number of physicians both in private practice (code 01, 02) and in hospitals (codes 03, 04, 05, 06) to the total number of physicians, i.e., 241,752 to 267,550. This ratio, when applied to the total number of physicians obtained from the source cited in footnote [c] (266,045), provides the figure 240,212 (physicians in private practice and in hospitals). Note that all of these figures exclude physicians in "government service" and "other" categories as defined by the AMA.

[e] Sum of 7,589 hospital facilities, 5,500 radiologists' offices and 39,515 private offices of other physicians with diagnostic x-ray equipment.

[f] Sum of 31,115 x-ray machine operators in hospital facilities, 20,350 operators in radiologists' offices, and 75,869 operators in private offices of other physicians with diagnostic x-ray equipment.

[g] Sum of 38,021 personnel occupationally exposed in hospital facilities, 23,595 personnel in radiologists offices and 92,070 personnel in private offices of other physicians with diagnostic x-ray equipment.

[h] Sum of 29,673 personnel monitored in hospital facilities; 17,710 personnel in radiologists' offices and 15,806 personnel in private offices of other physicians with diagnostic x-ray equipment.

[i] Footnote [d] reports 5,500 radiologists in private practice. The assumption is made that this number approximates closely the number of radiologists facilities. Data for radiologists' facilities obtained from medical x-ray protection surveys from the States indicates that there are 2.05 diagnostic x-ray machines per such facility: 5,500 × 2.05 = 11,275 x-ray machines in radiologists' offices. This leaves 40,821 diagnostic x-ray machines under the supervision of all other physicians. Data obtained from medical x-ray protection surveys as collected from the States indicates that on the average there are 1.03 diagnostic x-ray machines per facility with such equipment. Hence, 40,821 divided by 1.03 = 39,515 facilities. Therefore, personnel estimates for the group "physicians in private practice" are composites of best estimates for radiologists' facilities and for facilities of other physicians in private practice.

[j] A composite figure (as explained in footnote [i]). Average number of x-ray machine operators per radiologist's office = 3.70; per other M.D.'s private office = 1.92.

[k] A composite figure (as explained in footnote [i]). Average number of personnel occupationally exposed per radiologist's office = 4.29; per other private practice physicians = 2.33.

[l] A composite figure (as explained in footnote [i]). Average number of personnel monitored per radiologist's office = 3.22; per other physicians private offices = 0.40.

[m] Figures for hospitals were obtained by subtraction of private practice figures from figures presented for physician's total.

[n] This factor was derived by applying the average number of diagnostic x-ray machines in hospitals (as determined from an unpublished document, "Pilot Study of Characteristics of Practicing X-ray Technicians,") to the number of hospitals obtained from table 6 in "Hospital Statistics" J Amer Hospital Ass 15:474 (August 1, 1967).

[o] Derived from Medical X-ray Protection Surveys sent by the States to the X-ray Section, Medical and Occupational Radiation Program, Bureau of Radiological Health.

[p] HEALTH RESOURCES STATISTICS. Health Manpower, Number of physicians (doctors of osteopathy, for 1965, less federally employed and retired, table 74, p. 74 (1965) PHS Publication No. 1509. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[q] Ibid., p. 35. Chiropractors, 2nd paragraph, 1st sentence; Naturopaths and allied practitioners, 2nd paragraph, 1st sentence.

[r] Ibid., p. 157, table 121. Total number of veterinarians less retired category and those engaged exclusively in poultry practice.

[s] Ibid., p. 135. Podiatry, 2nd paragraph, 1st sentence.

[t] Estimated.

[u] HEALTH RESOURCES STATISTICS. Health Manpower, Total active non-federal dentists for the United States, table 26, p. 47 (1965) PHS Publication No. 1509. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[v] NATIONAL CENTER FOR RADIOLOGICAL HEALTH, STATE ASSISTANCE BRANCH. Dental X-ray Program Activities by State, Total Estimated Number of Units, SAB DOC 460-3-66 (June 1966) table 15, p. 27.

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SECTION I. MILK AND FOOD

Milk Surveillance, May 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents

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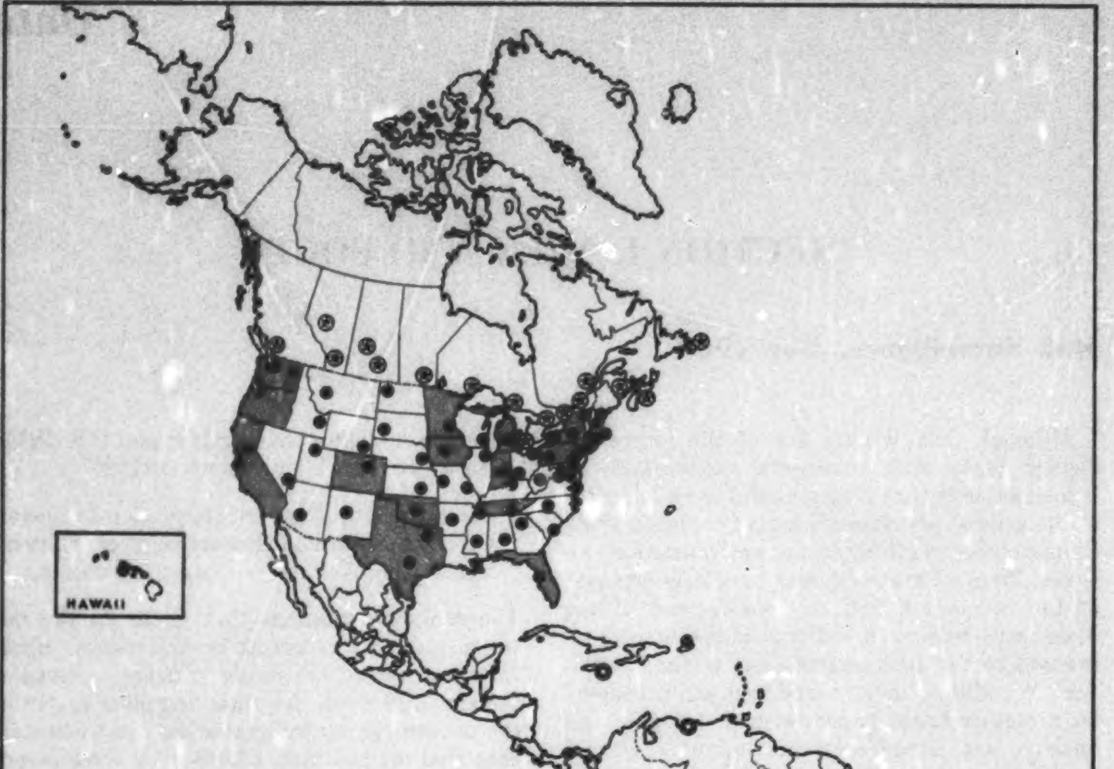
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Health Organization Sampling Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases of 20 to 30 percent from the expected values (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium–137 are relatively constant over short-time periods and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8*, *9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. The RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1- or 2- year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which, if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposi-

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels following an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000
Strontium-90	Bone marrow			[c]51,000
Cesium-137	Whole body			[c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

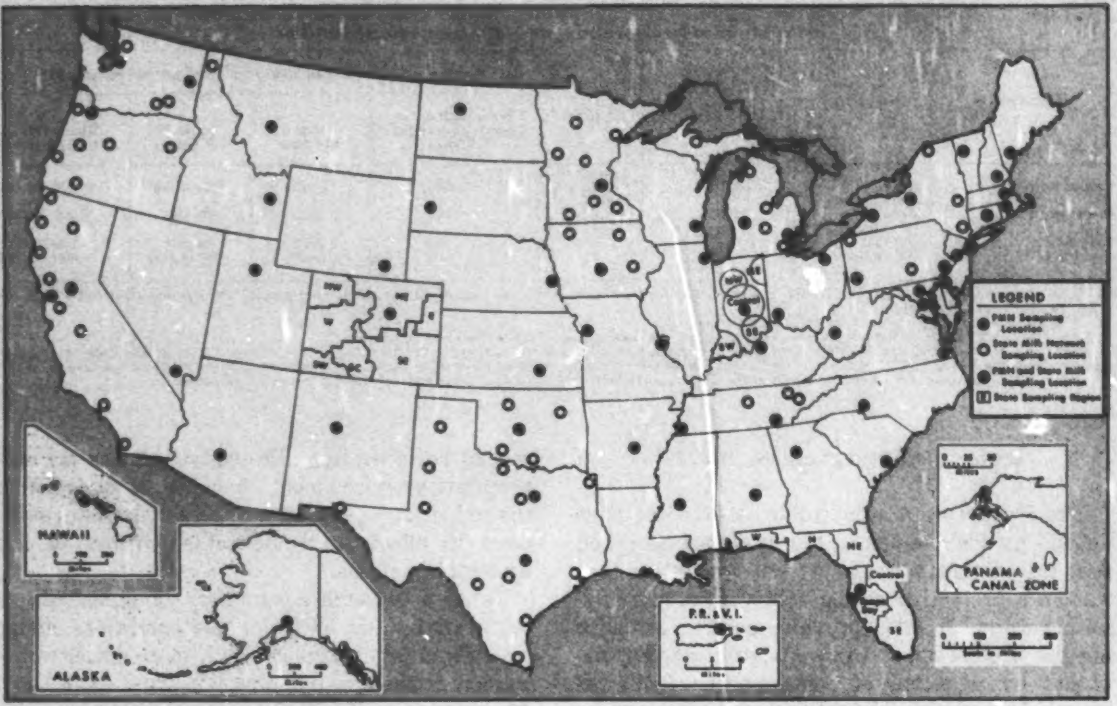

Figure 2. State and PMN milk sampling locations in the United States

tion and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3 surveillance results are given for strontium-90, iodine-131, and cesium-137 for May 1969 and the 12-month period, June 1968 to May 1969. Except where noted the monthly average represents a single sample for the sampling

Table 3. Concentration of radionuclides in milk for May 1969 and 12-month period, June 1968 through May 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES								
Ala:	Montgomery[c]	P	7	5	0 (5)	0	9 (5)	12
Alaska:	Palmer[c]	P	8	6	0 (3)	0	13 (3)	13
Ariz:	Phoenix[c]	P	0	0	0	0	0 (5)	1
Ark:	Little Rock[c]	P	22	21	0 (4)	0	20 (4)	19
Calif:	Sacramento[c]	P	4	1	0 (4)	0	0 (4)	2
	San Francisco[c]	P	4	2	0 (5)	0	0 (5)	2
	Del Norte	P	22	10	0	0	17	21
	Fresno	P	0	0	0	0	0	3
	Humboldt	P	8	4	0	0	0	11
	Los Angeles	P	0	1	0	0	0	4
	Mendocino	P	5	3	0	0	0	3
	Sacramento	P	4	2	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	12	5
	Shasta	P	4	3	0	0	0	6
	Sonoma	P	5	2	0	0	0	2
Colo:	Denver[c]	P	4	5	0 (4)	0	0 (4)	3
	West	R	(e)		(e) (3)	(e)	(e)	(e)
	Northeast	R	(e)		(e) (3)	(e)	(e)	(e)
	East	R	(e)		(e)	(e)	(e)	(e)
	Southeast	R	(e)		NS	(e)	NS	(e)
	South central	R	(e)		NS	(e)	NS	(e)
	Southwest	R	(e)		(e)	(e)	(e)	(e)
	Northwest	R	(e)		(e)	(e)	(e)	(e)
Conn:	Hartford[c]	P	8	9	0 (5)	0	11 (5)	12
	Central	P	6	7	0 (5)	0	7 (5)	10
Del:	Wilmington[c]	P	8	9	0 (4)	0	5 (4)	8
D.C.:	Washington[c]	P	9	9	0 (5)	0	2 (5)	3
Fla:	Tampa[c]	P	7	8	0 (4)	0	40 (4)	62
	West	R	12	12	0	3	19	24
	North	R	7	14	0	0	27	22
	Northeast	R	10	9	0	0	79	73
	Central	R	6	9	0	1	20	76
	Tampa Bay area	R	8	8	0	0	68	68
	Southeast	R	8	9	0	0	11	90
Ga:	Atlanta[c]	P	10	12	0 (4)	0	18	19
Hawaii:	Honolulu[c]	P	3	4	0 (4)	0	0 (4)	1
Idaho:	Idaho Falls[c]	P	5	6	0 (4)	0	0 (4)	8
Ill:	Chicago[c]	P	7	8	0 (3)	0	12 (3)	10
Ind:	Indianapolis[c]	P	8	8	0 (4)	0	3 (4)	6
	Northeast	P	9	11	0	0	5	10
	Southeast	P	7	9	0	0	10	9
	Central	P	8	8	0	0	15	11
	Southwest	P	8	8	0	0	13	12
	Northwest	P	10	10	0	0	10	12
Iowa:	Des Moines[c]	P	6	6	0 (4)	0	0 (4)	4
	Iowa City	P	NS					
	Des Moines	P	NS					
	Spencer	P	NS					
	Fredericksburg	P	NS					
Kans:	Wichita[c]	P	9	7	0 (4)	0	0 (4)	3
Ky:	Louisville[c]	P	NA	11	0 (5)	0	3 (5)	7
La:	New Orleans[c]	P	10	16	0 (4)	0	22 (4)	21
Maine:	Portland[c]	P	14	12	0 (4)	1	24 (4)	36
Md:	Baltimore[c]	P	11	10	0 (4)	0	6 (4)	8
Mass:	Boston[c]	P	11	12	0 (4)	0	21 (4)	24
Mich:	Detroit[c]	P	8	9	0 (4)	0	10 (4)	11
	Grand Rapids[c]	P	10	11	0 (4)	0	15 (4)	15
	Bay City	P	NA	14	NA	(e)	NA	5
	Charlevoix	P	12	9	(e) (4)	(e)	16 (4)	13
	Detroit	P	4		(e) (1)	(e)	8 (4)	10
	Grand Rapids	P	8	6	(e) (4)	(e)	7 (4)	10
	Lansing	P	5	5	(e) (2)	(e)	7 (2)	4
	Marquette	P	NA	9	(e) (2)	(e)	21 (2)	30
	Monroe	P	NA	9	(e) (2)	(e)	0 (2)	1
	South Haven	P	NA	7	(e) (5)	(e)	11	8
Minn:	Minneapolis[c]	P	10	11	0 (4)	0	2 (4)	14
	Bemidji	P	17	16	0	0	17	22
	Mankato	P	8	7	0	0	14	0
	Rochester	P	9	9	0	0	0	0
	Duluth	P	20	20	0	0	0	28
	Worthington	P	10	7	0	0	0	0
	Minneapolis	P	12	13	0	0	13	14
	Fergus Falls	P	8	0	0	0	12	11
	Little Falls	P	9	10	0	0	13	16
Miss:	Jackson[c]	P	15	15	0 (4)	0	13 (4)	16
Mo.:	Kansas City[c]	P	7	7	0 (5)	0	0 (5)	2
	St. Louis[c]	P	10	9	0 (5)	0	6 (5)	5
Mont:	Helena[c]	P	4	5	0 (3)	0	3 (3)	8
Nebr:	Omaha[c]	P	7	6	0 (5)	0	2 (5)	3
Nev:	Las Vegas[c]	P	0	1	0 (4)	0	0 (4)	1
N.H.:	Manchester[c]	P	10	12	0 (4)	0	23 (4)	32

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for May 1969 and 12-month period, June 1968 through May 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[c]	12-month average
UNITED STATES—Continued								
N.J.:	Trenton*	P	9	9	0 (4)	0	9 (4)	10
N. Mex:	Albuquerque*	P	3	2	0 (4)	0	0 (4)	2
N.Y.:	Buffalo*	P	7	8	0 (5)	0	7 (5)	10
	New York City*	P	10	11	0 (4)	0	5 (4)	14
	Syracuse*	P	7	8	0 (4)	0	12 (4)	9
	Albany	P	10	8	0 (4)	0	0 (4)	0
	Buffalo	P	7	0	0	0	0	0
	Massena	P	9	9	0 (2)	0	0 (2)	0
	Newburg	P	5	11	0 (2)	0	0 (2)	0
	New York City	P	12	12	0 (4)	0	0 (4)	0
	Syracuse	P	7	9	0 (2)	0	0 (2)	0
N.C.:	Charlotte*	P	13	15	0 (4)	0	15 (4)	12
N. Dak:	Minot*	P	11	11	0 (2)	0	13 (2)	13
Ohio:	Cincinnati*	P	8	9	0 (4)	0	2 (4)	5
	Cleveland*	P	8	9	0 (5)	0	9 (5)	8
Okla:	Oklahoma City*	P	11	9	0 (3)	0	5 (3)	7
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland*	P	11	8	0 (5)	0	10 (5)	11
	Baker	P	6	2	(*)	(*)	(*)	8
	Coos Bay	P	14	8	(*)	(*)	(*)	15
	Eugene	P	4	4	(*)	(*)	17	13
	Medford	P	4	2	(*)	(*)	(*)	14
	Portland composite	P	8	5	(*)	(*)	(*) (5)	6
	Portland local	P	9	5	(*)	(*)	16 (5)	6
	Redmond	R	4	2	(*)	(*)	(*)	6
	Tillamook	P	14	8	(*)	(*)	20	25
Pa:	Philadelphia*	P	9	10	0 (4)	0	1 (4)	8
	Pittsburgh*	P	10	12	0 (4)	0	2 (4)	10
	Dauphin	P	8	8	0	0	17	19
	Erie	P	11	11	0	0	15	23
	Philadelphia	P	NS	10	NS	0	NS	18
	Pittsburgh	P	11	11	0	0	15	16
R.I.:	Providence*	P	5	10	0 (4)	0	12 (4)	10
S.C.:	Charleston*	P	13	13	0 (4)	0	24 (4)	24
S. Dak:	Rapid City*	P	0	8	0 (4)	0	4 (4)	9
Tenn:	Chattanooga*	P	11	13	0 (4)	0	6 (4)	13
	Memphis*	P	12	10	0 (5)	0	2 (5)	3
	Chattanooga	P	16	11	4	0	13 (4)	16
	Clinton	P	14	13	0 (2)	0	14 (2)	18
	Knoxville	P	11	9	0 (2)	1	14 (2)	10
	Nashville	P	12	9	0 (2)	0	6 (2)	7
Tex:	Austin*	P	3	3	0 (4)	0	7 (4)	2
	Dallas*	P	10	8	0 (4)	0	4 (4)	7
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	7	4	0	0	0	0
	El Paso	R	3	2	0	0	0	0
	Fort Worth	R	NS	6	NS	0	NS	0
	Harlingen	R	NS	4	NS	0	NS	0
	Houston	R	NS	9	NS	0	NS	0
	Lubbock	R	3	4	0	0	0	2
	Midland	R	NS	3	NS	0	NS	0
	San Antonio	R	NS	2	NS	0	NS	0
	Texarkana	R	5	9	0	0	10	15
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	NS	9	NS	0	NS	0
Utah:	Salt Lake City*	P	6	5	0 (4)	0	0 (4)	0
Vt:	Burlington*	P	8	9	0 (4)	0	11 (4)	11
Va:	Norfolk*	P	11	11	0 (5)	0	7 (5)	9
Wash:	Seattle*	P	13	9	0 (5)	0	13 (5)	18
	Spokane*	P	8	7	0 (4)	0	1 (4)	7
	Benton County	R	3	1	0	0	0	6
	Franklin County	R	NS	1	NS	0	NS	0
	Sandpoint, Idaho	R	13	9	0	0	22	25
	Skagit County	R	9	8	0	0	29	12
W. Va:	Charleston*	P	11	12	0 (3)	0	10 (3)	9
Wis:	Milwaukee*	P	6	7	0 (4)	0	11 (4)	13
Wyo:	Laramie*	P	6	5	0 (4)	0	0 (4)	11
CANADA								
Alberta:	Calgary	P	8	8	(d)		9	17
	Edmonton	P	6	8	(d)		13	18
British Columbia:	Vancouver	P	13	13	(d)		34	44
Manitoba:	Winnipeg	P	9	8	(d)		21	24
New Brunswick:	Fredericton	P	11	14	(d)		16	21
Newfoundland:	St. Johns	P	13	10	(d)		17	20
Nova Scotia:	Halifax	P	13	11	(d)		18	20
Ontario:	Ft. William	P	15	16	(d)		24	33

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for May 1969 and 12-month period, June 1968 through May 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
Ontario:	Ottawa	P	7	8	[d]		10	10
	Sault Ste. Marie	P	16	15	[d]		27	34
	Toronto	P	5	5	[d]		7	14
	Windsor	P	5	6	[d]		8	13
Quebec:	Montreal	P	7	8	[d]		15	19
	Quebec	P	12	12	[d]		29	28
Saskatchewan:	Regina	P	7	7	[d]		10	17
	Saskatoon	P	10	9	[d]		15	17
CENTRAL AND SOUTH AMERICA								
Columbia:	Bogota	P	NS	1	NS	0	NS	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Mandeville	P	3	5	0	0	60	100
Venezuela:	Caracas	P	0	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	2	0 (4)	1	6 (4)	14
Puerto Rico:	San Juan[c]	P	4	5	0 (4)	0	9 (4)	8
PMN network average[f]			8	8	0	0	8	11

[a] P, pasteurized milk; R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or national network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [c].

NA, no analysis.
NS, no sample collected.

station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for May 1969 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which and barium-140 was detected.

Table 4. Barium-140 in milk, May 1969

Sampling location		Monthly average (pCi/liter)
		Barium-140
Tenn:	Chattanooga (State)	5(4)
	Clinton (State)	6(2)
	Knoxville (State)	6(2)

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (see table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 22 pCi/liter in the United States for the month of May 1969 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark.,) representing 10.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 79 pCi/liter in the United States for the month of May 1969 and the highest 12-month average was 76 pCi/liter (central Florida), representing 2.1 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level except Chattanooga, Tenn. (State) 4 pCi/liter.

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Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Connecticut Diet Study	January–June 1968	November 1968
Institutional Diet Study, *PHS*	October–December 1968	July 1969
Tri-City Diet, *HASL*	January–June 1968	April 1969

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Drinking Water Analysis Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
Minnesota	January–June 1968	February 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	January–June 1968	April 1969
Washington	July 1967–June 1968	June 1969

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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Gross Radioactivity in Surface Waters of the United States February 1969

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the

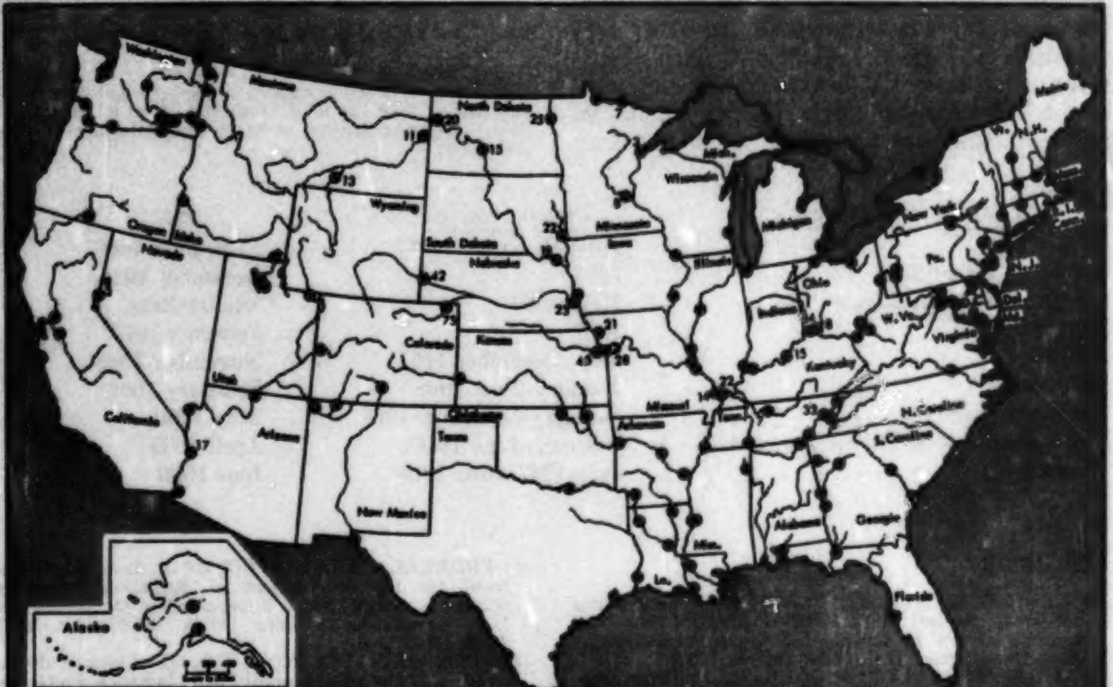
Washington
Montana
North Dakota
20
23
11
13
13
7
Maine
Vt.
N.H.
Wisconsin
Mich.
Wyoming
Minnesota
Michigan
New York
22
Oregon
Idaho
South Dakota
Iowa
Nevada
Nebraska
19
Illinois
Pa.
42
Ohio
N.J.
Del.
25
Indiana
W. Va.
73
21
8
Virginia
Colorado
Kansas
45
28
15
Kentucky
Utah
22
14
33
N. Carolina
California
Missouri
Oklahoma
Tenn.
Arkansas
Arizona
Texas
S. Carolina
17
New Mexico
Alabama
Georgia
Miss.
La.
Florida
Alaska

Figure 1. Sampling locaions and associated total beta radioactivity (pCi/liter) in surface waters, February 1969

Table 1. Radioactivity in raw surface waters, February 1969

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
BIG HORN RIVER:						
Hardin, Mont.	0	4	4	2	11	13
BIG SIOUX RIVER:						
Sioux Falls, S. Dak.	0	5	5	1	21	22
CLINCH RIVER:						
Kingston, Tenn.	0	0	0	1	31	32
COLORADO RIVER:						
Parker Dam, Calif–Ariz.	0	9	9	1	16	17
CUMBERLAND RIVER:						
Cheatham Lock, Tenn.	1	0	1	4	3	7
GREAT LAKES:						
Duluth, Minn.	0	0	0	0	3	3
KANSAS RIVER:						
DeSoto, Kans.	13	2	15	32	13	45
LITTLE MIAMI RIVER:						
Cincinnati, Ohio	1	0	1	5	3	8
MISSISSIPPI RIVER:						
St. Paul, Minn.	0	1	1	0	8	8
Cape Girardeau, Mo.	1	0	1	5	9	14
MISSOURI RIVER:						
Williston, N. Dak.	1	3	4	9	11	20
Bismarck, N. Dak.	0	3	3	2	13	15
Yankton, S. Dak.	0	2	2	0	18	18
St. Joseph, Mo.	1	7	8	2	19	21
Missouri City, Mo.	3	3	6	14	14	28
NORTH PLATTE RIVER:						
Henry, Nebr.	<1	30	30	4	38	42
OHIO RIVER:						
Cincinnati, Ohio	3	0	3	10	4	14
Louisville, Ky.	1	1	2	8	7	15
Cairo, Ill.	6	0	6	16	6	22
PLATTE RIVER:						
Plattsmouth, Nebr.	1	4	5	4	19	23
RAINY RIVER:						
International Falls, Minn.	0	0	0	0	7	7
RED RIVER, NORTH:						
Grand Forks, N. Dak.	0	1	1	3	22	25
SOUTH PLATTE RIVER:						
Julesburg, Colo.	1	38	39	9	66	75
YELLOWSTONE RIVER:						
Sidney, Mont.	0	2	2	0	11	11
Maximum	13	38	39	32	66	75
Minimum	0	0	0	0	3	3

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations for 1961 through 1965 has been presented (7). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During February 1969, the following stations showed alpha radioactivity values in excess of 15 pCi/liter for either suspended or dissolved solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

None of the stations showed a beta radioactivity value in excess of 150 pCi/liter during February 1969.

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(2) *Ibid.*, 1959 Edition.

(3) *Ibid.*, 1960 Edition.

(4) *Ibid.*, 1961 Edition.

(5) *Ibid.*, 1962 Edition.

(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

(7) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

Radioactivity in New York Surface Waters July-December 1968

Division of General Engineering and
Radiological Health
State of New York Department of Health

In 1955 the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations.

Analytical procedures

A measured quantity of water, usually 500 ml, is evaporated and the residue is analyzed for its beta component in an end window, gas flow, proportional counter.

Strontium and alkaline earths are precipitated as carbonates from a 500-ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulphate from a pH controlled EDTA solution. Calcium and yttrium remain in solution as EDTA complexes (1–2).

Strontium-90 is determined by yttrium-90 ingrowth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas-flow, proportional beta-particle counter. Strontium-89 is estimated by

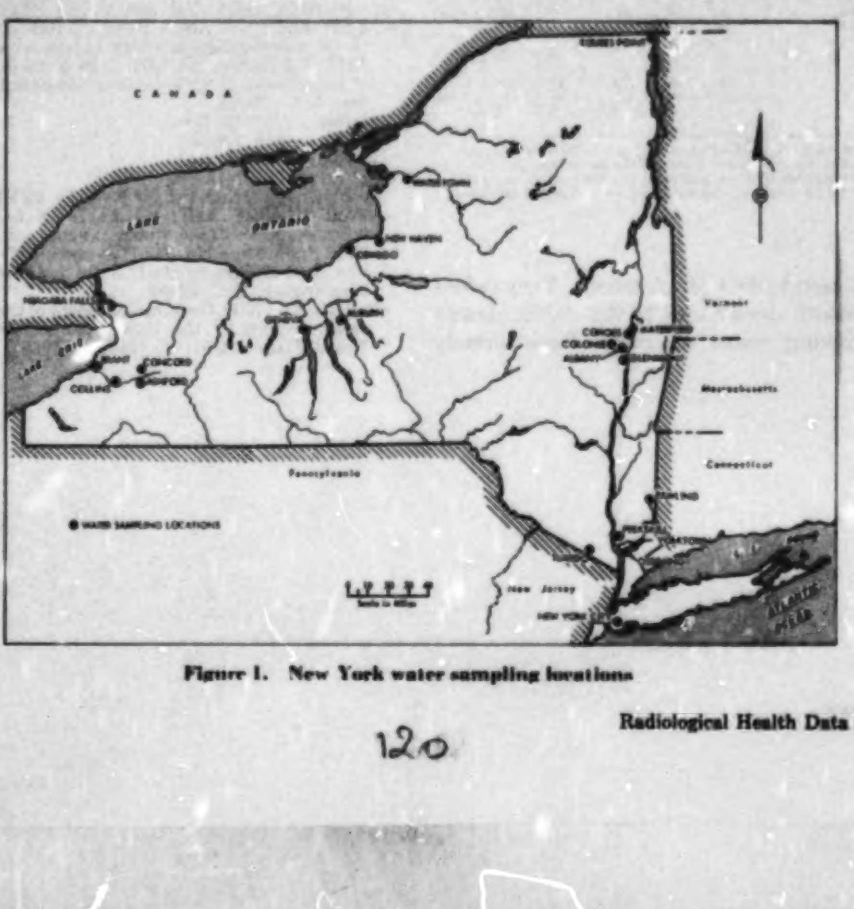
CANADA
LAKE ONTARIO
NIAGARA FALLS
LAKE ERIE
CONCORD
Pennsylvania
● WATER SAMPLING LOCATIONS
Scale in Miles
Vermont
COHOES
COLONIE
ALBANY
Massachusetts
Connecticut
New Jersey
NEW YORK
ATLANTIC OCEAN

Figure 1. New York water sampling locations

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Table 1. Gross beta radioactivity in New York raw surface waters, July–December 1968[a]

Location	Gross beta radioactivity (pCi/liter)							
	July–September 1968				October–December 1968			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	2	3	3	2	3	2	3	2
Ashford (Buttermilk Creek at Fox Valley Road)	3	9	16	4	3	5	6	4
(Buttermilk Creek at Thomas Corners)[b]	16	1,518	2,[illegible]	110	12	806	2,141	190
(Cattaraugus Creek at Bigelow Bridge)	3	7	12	3	3	6	10	3
(Cattaraugus Creek at Felton Bridge)	5	282	721	153	—	NA	NA	NA
Brant (Cattaraugus Creek)	15	47	67	20	12	60	123	26
[illegible] (Filtration Plant)	11	3	6	1	11	3	7	2
Collins (Cattaraugus Creek)	13	74	186	29	13	86	108	22
Concord (Cattaraugus Creek)	42	128	275	6	63	148	258	31
Geneva (Seneca Lake)	3	4	5	3	3	3	4	3
Glenmont (Hudson River)	12	4	7	2	11	4	7	2
New Haven (Lake Ontario)	3	4	4	1	2	4	4	4
New York City	6	3	4	1	2	2	3	ND
Niagara Falls (West Branch, Niagara River)	3	4	4	3	2	4	4	4
Ossining (Indian Brook Reservoir)	3	5	5	5	3	5	5	5
(Sing Sing) (Hudson River)	12	31	59	ND	12	33	60	ND
Oswego	1	2	NA	NA	3	4	4	4
Pawling (Pond at United Nuclear)	5	3	4	2	4	3	3	3
Peekskill (Camp Field Water Supply)	3	5	10	ND	3	ND	ND	ND
(Hudson River)	11	21	28	3	11	25	46	ND
Tuxedo (Indian Kill)	4	4	4	1	3	3	4	3
Watertown (Black River)	11	2	4	2	7	4	5	3
Yorktown (Croton Reservoir)	3	4	4	3	3	3	4	3

[a] Excluding tritium.
[b] This station is on the Nuclear Fuels Services reprocessing plant site.
NA, no analysis.
ND, nondetectable.

Table 2. Strontium-90 concentration in New York surface waters, July–December 1968

Location	Strontium-90 (pCi/liter)							
	July–September 1968				October–December 1968			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Ashford (Buttermilk Creek at Thomas Corners)[a]	10	360	1,015	72	10	465	871	187
(Cattaraugus Creek at Felton Bridge)	1	231	NA	NA	—	NA	NA	NA
Concord (Springville Power Dam on Cattaraugus Creek)	3	25	38	15	1	38	NA	NA

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
NA, no analysis.

taking the difference between the total strontium and the strontium-90 radioactivity.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ±100 percent at the 95 percent confidence level.

Tritium in water is determined by liquid scintillation counting of 3 ml of distilled sample in 17 ml of scintillator solution. The scintillator solution consists of 4 g PPO, 0.25 g dimethyl POPOP and 120 g naphthalene dissolved in 1 liter of dioxane. The sample is counted twice for a total of 100 minutes using either a Packard Tri-Carb model 3315 or a Beckman LS 200B Liquid scintillation spectrometer. Minimum sensitivites at the 95 percent confidence level ±100 percent are 1,000 pCi/liter for the Tri-Carb and 500 pCi/liter for the Beckman.

Discussion and results

With the exception of Buttermilk and Cattaraugus Creeks downstream of Nuclear Fuel Services, the results of water sampling stations in the State remain low. Water samples are obtained from 23 locations for gross beta-particle analysis (figure 1). The type of sample, number of samples, quarterly average, maximum and minimum gross beta-particle concentrations in New York surface water for July-December 1968 are given in table 1.

Table 3. Tritium concentration of New York surface waters, July–December 1968

Location	Concentration (pCi/liter)							
	July–September 1968				October–December 1968			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	ND	1,590	ND	3	1,000	1,130	ND
Ashford (Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	1,120	ND
(Buttermilk Creek at Thomas Corners)ª	14	658,900	1,134,000	149,900	12	71,380	205,300	3,300
(Cattaraugus Creek at Bigelow Bridge)	3	1,700	4,190	ND	3	ND	1,040	ND
(Cattaraugus Creek at Felton Bridge)	3	34,970	95,040	32,080	—	NA	NA	NA
Brant (Cattaraugus Creek)	11	27,440	30,350	10,480	12	8,980	29,830	2,410
Cohoes (Filtration Plant)	11	ND	2,200	ND	11	ND	1,300	ND
Collins (Cattaraugus Creek)	13	33,980	69,440	6,770	13	10,540	39,770	1,100
Concord (Springville Power Dam on Cattaraugus Creek)	41	51,510	110,400	7,330	62	16,080	71,670	2,700

ª This station is on the Nuclear Fuels Services reprocessing plant site.
ND, nondetectable.
NA, no analysis.

Larger samples are collected at selected locations for strontium-90 analysis. The number of samples, average, maximum, and minimum concentrations of strontium-90 in New York water for the third and fourth quarters of 1968 are given in table 2 for three stations where strontium-90 was detected.

Tritium concentration values for the third and fourth quarters of 1968 are given in table 3 for nine locations. Tritium, the radioactive isotope of hydrogen, a very low energy beta-particle emitter is released to the water courses during the reprocessing of nuclear fuel. The tritium concentrations in Cattaraugus and Buttermilk Creeks showed the contribution of the Nuclear Fuel reprocessing plant.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
June–December 1967	October 1968
January–June 1968	April 1969

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium-90 in milk by ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(*2*) WELFORD, G., and D. SUTTON, a paper presented at the American Chemical Society meeting in New York City, September 1960.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

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1. Radiation Alert Network
May 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during May 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

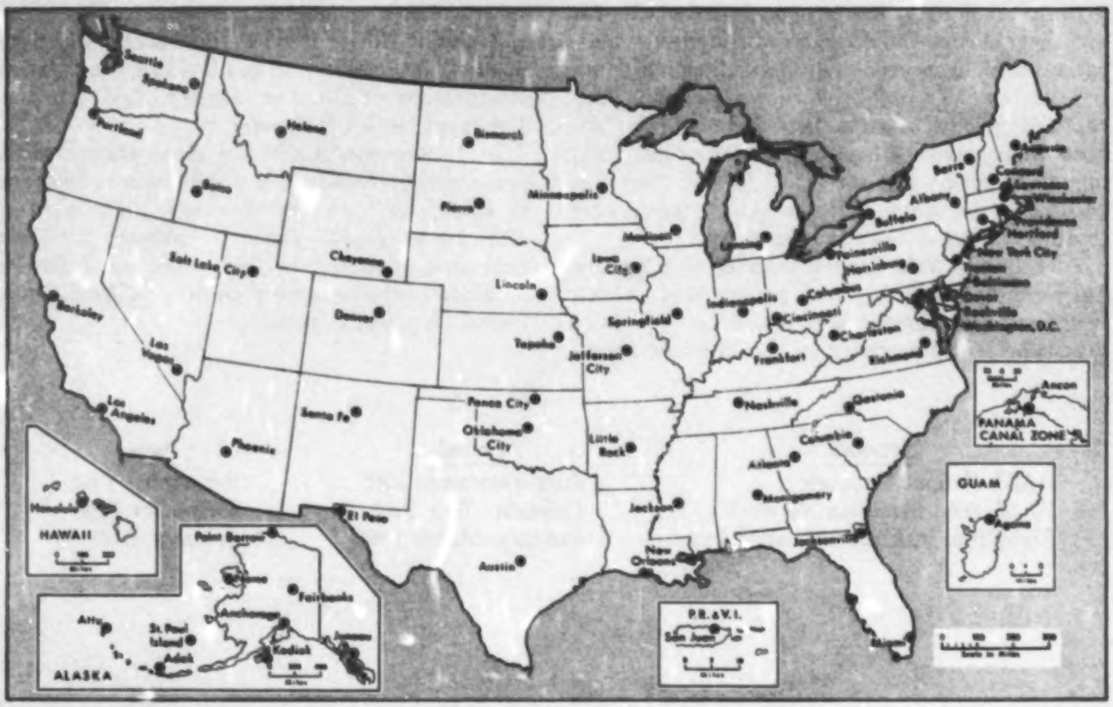
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Salt Lake City
Cheyenne
Iowa City
Lincoln
Denver
Berkeley
Las Vegas
Topeka
Jefferson City
Springfield
Indianapolis
Columbus
Cincinnati
Frankfort
Charleston
Richmond
Los Angeles
Santa Fe
Phoenix
Ponca City
Oklahoma City
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
El Paso
Austin
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
ALASKA
Augusta
Concord
Lawrence
Barre
Albany
Buffalo
Winchester
Providence
Hartford
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, May 1969

Station location		Number of samples	Air surveillance, gross beta radioactivity (pCi/m^3)			Last profile in RHD&R	Precipitation				
		Air	Maximum	Minimum	Average [a]		Number of samples	Total depth (mm)	Field estimation of deposition: Number of samples	Depth (mm)	Total deposition (nCi/m^2)
Ala:	Montgomery	21	3	0	2	Feb 69	4	125	4	125	26
Alaska:	Adak	21	2	1	1	Feb 69	(e)				
	Anchorage	10	0	0	0	Oct 68	(e)				
	Attu Island	23	0	0	0	Mar 69	(e)				
	Fairbanks	(b)				Sept 69	(e)				
	Juneau	21	0	0	0	Dec 68	9	140	8	137	0
	Kodiak	(b)				Jan 69	(e)				
	Nome	(b)				May 69	(e)				
	Point Barrow	30	0	0	0	Apr 69	(e)				
	St. Paul Island	10	1	1	1	June 69	(e)				
Ariz:	Phoenix	21	7	1	4	Dec 68	(e)				
Ark:	Little Rock	6	4	0	2	Aug 69	(e)				
Calif:	Berkeley	21	1	0	0	Jan 69	1	20	0	0	(c)
	Los Angeles	21	1	0	0	May 69	(e)				
C.Z:	Ancon	17	0	0	0	Jan 69	(e)				
Colo:	Denver	18	7	1	2	Jan 69	5	182	(d)		
Conn:	Hartford	21	1	0	0	Sept 69	6	39	6	30	0
Del:	Dover	20	1	0	0	July 69	(e)				
D.C:	Washington	16	1	0	0	Apr 69	2	9	2	9	0
Fla:	Jacksonville	19	2	0	1	Aug 69	5	37	3	37	35
	Miami	17	0	0	0	Sept 69	11	229	10	223	0
Ga:	Atlanta	20	2	1	1	June 69	3	220	3	229	239
Guam:	Agana	(b)				July 69	(e)				
Hawaii:	Honolulu	27	6	0	1	Mar 69	(e)				
Idaho:	Boise	18	4	1	2	Mar 69	4	17	4	17	0
Ill:	Springfield	19	5	1	3	Apr 69	(e)				
Ind:	Indianapolis	20	2	0	2	June 69	3	36	3	36	41
Iowa:	Iowa City	18	4	0	1	Jan 69	4	80	4	80	0
Kans:	Topeka	19	3	0	1	Aug 69	3	92	3	92	0
Ky:	Frankfort	3	1	1	1	Apr 69	(e)				
La:	New Orleans	20	1	0	1	Apr 69	8	161			
Maine:	Augusta	21	1	0	0	May 69	8	68	8	68	0
Md:	Baltimore	21	1	0	0	Sept 69	2	20	2	20	12
	Rockville	12	1	0	1	Mar 69	(e)				
Mass:	Lawrence	20	1	0	0	July 69	4	26	4	26	2
	Winchester	21	2	0	1	Feb 69	4	36	4	36	0
Mich:	Lansing	21	4	0	2	Mar 69	7	102	7	102	132
Minn:	Minneapolis	21	1	0	0	July 69	9	42	9	42	6
Miss:	Jackson	18	2	0	1	May 69	1	25	1	25	0
Mo:	Jefferson City	21	2	0	1	June 69	8	68	8	68	0
Mont:	Helena	20	9	1	4	Feb 69	1	1	1	1	2
Nebr:	Lincoln	16	4	1	3	June 69	4	67	4	67	18
Nev:	Las Vegas	14	2	0	1	Sept 69	(e)				
N.H:	Concord	21	1	0	0	Apr 69	(e)				
N.J:	Trenton	21	3	0	1	May 69	1	15	1	15	0
N. Mex:	Santa Fe	6	2	0	1	Feb 69	4	40	4	40	0
N.Y:	Albany	15	3	0	1	June 69	6	60	6	60	30
	Buffalo	21	2	0	1	Jan 69	(e)				
	New York City	20	1	0	0	Feb 69	(e)				
N.C:	Gastonia	17	12	1	5	Jan 69	2	28	(d)		
N.Dak:	Bismarck	20	3	1	2	Apr 69	5	35	5	35	0
Ohio:	Cincinnati	(b)				July 69	(e)				
	Columbus	16	6	0	1	May 69	5	73	0	0	(c)
	Painesville	19	2	0	1	Sept 69	6	66	6	66	0
Okla:	Oklahoma City	18	1	0	0	Mar 69	3	74	3	74	0
	Ponca City	21	2	0	1	Sept 69	5	63	5	63	27
Ore:	Portland	17	1	0	1	June 69	7	33	7	33	6
Pa:	Harrisburg	2	0	0	0	June 69	(e)				
P.R:	San Juan	(b)				May 69	(e)				
R.I:	Providence	20	1	0	0	Mar 69	4	30	4	30	23
S.C:	Columbia	14	2	0	1	Feb 69	2	71	2	71	9
S. Dak:	Pierre	8	6	2	4	Dec 68	(e)				
Tenn:	Nashville	7	2	0	1	Mar 69	2	23	2	23	0
Tex:	Austin	20	6	1	2	July 69	5	65			
	El Paso	(b)				Apr 69	(e)				
Utah:	Salt Lake City	20	6	1	2	May 69	2	3	2	3	1
Vt:	Barre	20	2	0	1	Aug 69	10	81	10	81	0
Va:	Richmond	21	0	0	0	Aug 69	4	52	4	52	9
Wash:	Seattle	8	1	0	0	Aug 69	7	52	(d)		
	Spokane	21	2	0	1	July 69	(e)				
W. Va:	Charleston	14	3	0	1	Feb 69	6	41	6	41	6
Wis:	Madison	20	2	0	1	Aug 69	9	67	9	67	51
Wyo:	Cheyenne	21	10	2	4	Sept 69	3	42	3	42	20
Network summary		1,180	12	0	1		5	65	5	62	20

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

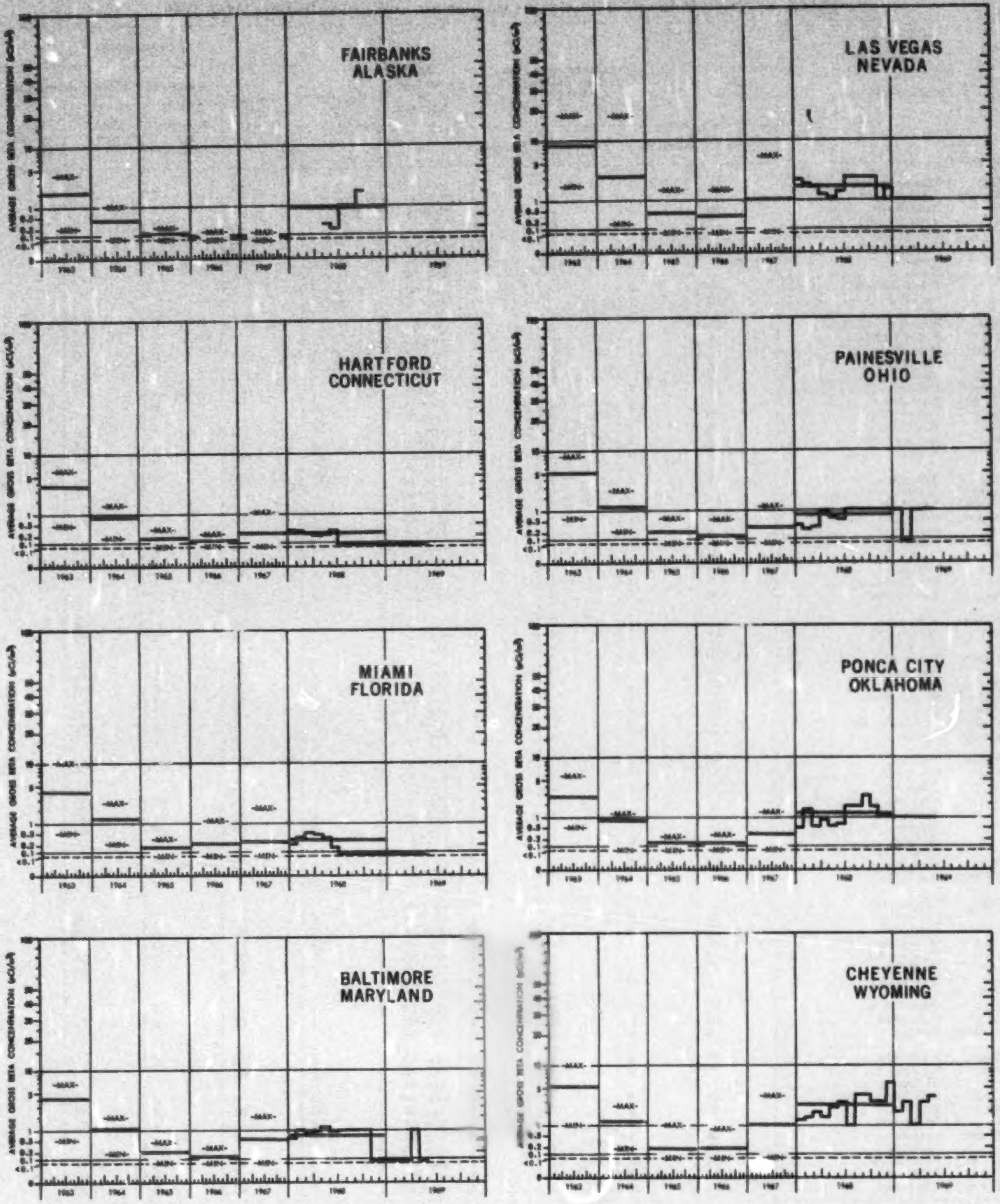

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–May 1969

2. Canadian Air and Precipitation Monitoring Program[1] May 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the August 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for May 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, May 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	26	0.7	0.0	0.3	NS	NS
Coral Harbour	31	.1	.0	.1	31	1.0
Edmonton	31	.5	.0	.2	193	6.4
Ft. Churchill	30	.2	.0	.1	45	1.5
Ft. William	17	.3	.0	.2	138	8.9
Fredericton	29	.3	.0	.1	65	4.5
Goose Bay	31	.2	.0	.1	15	.8
Halifax	30	.4	.0	.1	56	4.6
Inuvik	31	.2	.0	.1	52	1.0
Montreal	31	.4	.0	.2	52	7.9
Moosonee	31	.3	.0	.1	21	8.3
Ottawa	30	.4	.0	.2	88	6.0
Quebec	30	.3	.0	.1	51	8.3
Regina	31	.7	.0	.2	245	6.0
Resolute	28	.2	.0	.1	30	.2
St. John's, Nfld	30	.2	.0	.1	59	7.9
Saskatoon	31	.5	.0	.2	128	5.8
Soulte Ste. Marie	31	.5	.1	.2	144	8.5
Toronto	30	.5	.0	.2	65	4.7
Vancouver	31	.5	.0	.2	179	4.7
Whitehorse	30	.5	.0	.2	207	1.0
Windsor	31	.4	.0	.2	52	6.1
Winnipeg	31	.5	.1	.2	130	9.9
Yellowknife	31	.2	.0	.2	48	1.0
Network summary	703	0.7	0.0	0.2	94	4.7

NS, no sample.

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[1] Prepared from information and data in the June 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

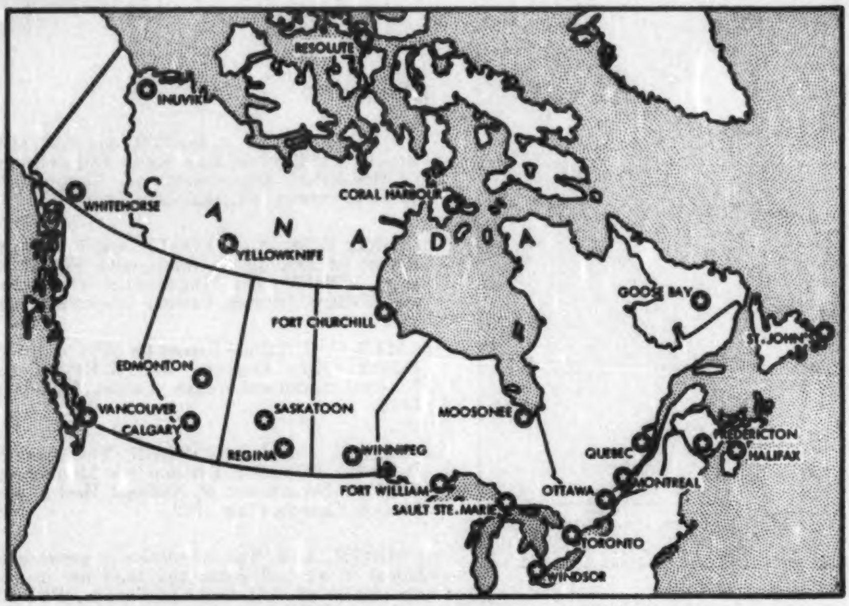
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
MOOSONEE
VANCOUVER
CALGARY
SASKATOON
FREDERICTON
HALIFAX
QUEBEC
REGINA
WINNIPEG
FORT WILLIAM
MONTREAL
OTTAWA
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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3. Pan American Air Sampling Program May 1969

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The May 1969 air monitoring results from the participating countries are given in table 3.

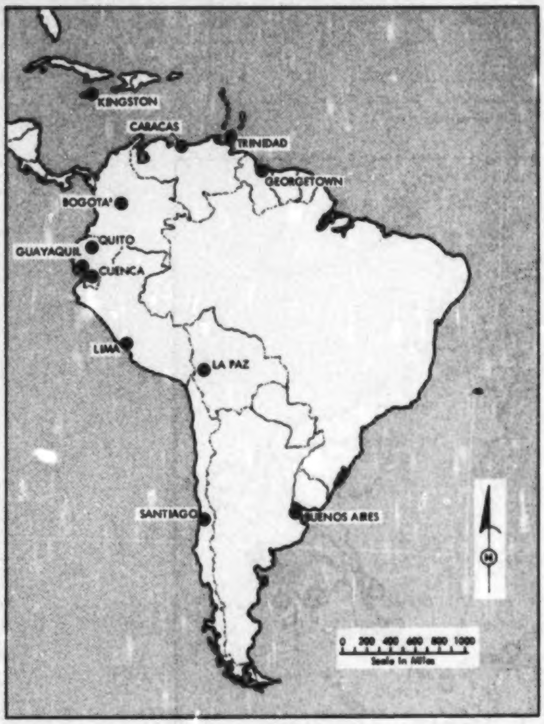

Figure 4. Pan American Air Sampling Program station

Table 3. Summary of gross beta radioactivity in Pan American surface air, May 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average^a
Argentina:	Buenos Aires	11	0.10	0.02	0.06
Bolivia:	La Paz	12	.35	.11	.23
Chile:	Santiago	31	.70	.32	.46
Colombia:	Bogota	14	.47	.16	.28
Ecuador:	Cuenca	23	.26	.00	.10
	Guayaquil	20	.32	.11	.23
	Quito	10	.26	.12	.22
Guyana:	Georgetown	15	.93	.66	.78
Jamaica:	Kingston	20	.41	.13	.28
Peru:	Lima	NS			
Venezuela:	Caracas	19	.34	.11	.22
West Indies:	Trinidad	17	.33	.17	.26
Pan American summary		192	0.70	0.00	0.29

^a The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no sample.

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(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Bone, July-September 1968[1]

Bureau of Radiological Health
Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at Northeastern Radiological Health Laboratory of the Bureau of Radiological Health, at Winchester, Mass. Sample collection and preparation are explained else-

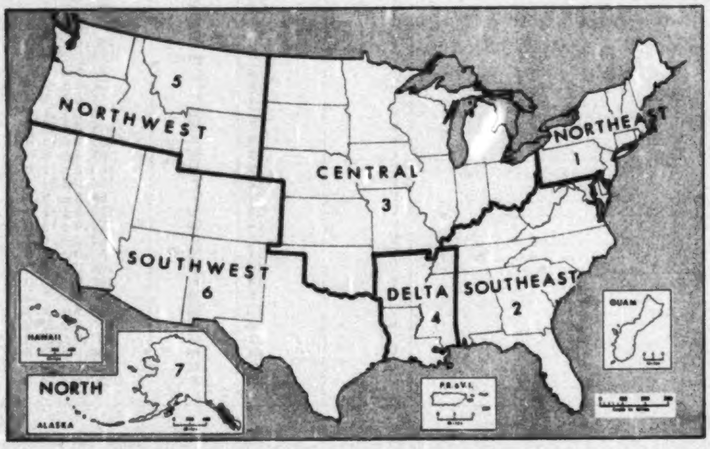

Figure 1. Geographical regions for human bone sampling

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[1] Period during which death or surgical procedure occured.

Table 1. Strontium-90 in human bone, July–September 1968

Bone region and State		Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:	N.J.	V, R, S	0	F	087.7± 7.8	20.9	4.19
		V, S	1	F	51.2± 5.2	18.3	2.79
	Mass.	V	2	M	11.6±13.0	25.5	0.45
	R.I.	V	3	M	82.9±10.0	27.5	3.01
	N.Y.	V	3	F	169.0±16.0	53.7	3.14
	Conn.	R, T	9	M	297.0±25.0	93.4	3.17
	Vt.	V	9	F	92.8± 7.6	31.8	2.91
	Vt.	V	9	F	92.8± 7.6	31.8	2.91
	N.Y.	V	12	F	104.0± 8.3	37.4	2.78
	Conn.	V, R	12	M	61.7± 6.8	28.6	2.15
	Mass.	V	13	M	112.0± 8.5	43.1	2.60
		V	14	M	63.2± 6.4	28.6	2.21
	Maine	V	15	M	253.0±13.0	49.5	5.09
	Mass.	V	16	M	146.0±11.0	39.1	3.73
	N.Y.	V	16	M	162.0±13.0	43.9	3.69
		V	18	M	139.0±10.0	41.6	3.34
	Conn.	V	18	M	77.5± 7.1	35.9	2.16
	N.Y.	V	19	F	102.0± 9.4	45.1	2.26
	Pa.	V	19	M	91.7± 9.4	44.9	2.04
	N.Y.	V	19	M	159.0±11.0	48.4	3.28
	Vt.	V	20	F	70.6±10.0	51.5	1.37
	N.Y.	V	20	M	105.0± 9.3	47.2	2.22
	Maine	V	21	M	178.0±14.0	46.4	3.83
	Conn.	V, R	22	M	102.0±12.0	50.1	2.03
	N.Y.	V	22	M	110.0±12.0	75.4	1.46
	N.Y.	V	25	F	100.0± 8.8	41.6	2.40
Southeast.	S.C.	V	2	M	208.0±27.0	60.3	3.44
		V	3	F	164.0±15.0	53.9	3.04
		V	5	M	277.0±18.0	36.7	7.54
	Md	V	9	M	77.8± 9.8	36.5	2.13
	S.C.	V	11	F	91.2± 8.9	29.7	3.07
	Md	V	12	M	66.1± 7.0	34.8	1.90
		V	12	F	90.9±10.0	36.7	2.47
		V	13	M	83.9±10.0	38.0	2.20
		V	13	M	82.0±11.0	29.3	2.80
		V	13	M	102.0± 9.4	37.8	2.70
	S.C.	V	13	M	62.7± 6.9	30.7	2.04
	Ga.	V	14	M	120.0±11.0	44.7	2.68
	Md	V	16	F	194.0±15.0	53.8	3.61
		V	16	M	158.0±12.0	58.9	2.68
		V	17	M	97.8± 9.3	51.7	1.89
		V	17	M	222.0±13.0	45.6	4.86
		V	18	F	103.0±15.0	58.8	1.75
		V	18	M	135.0±12.0	49.1	2.74
		V	18	F	163.0±13.0	50.1	3.25
	S.C.	V	18	M	152.0±10.0	52.1	2.91
	Md	V	19	M	105.0±10.0	49.8	2.10
		V	19	M	227.0±18.0	59.7	3.80
		V	19	M	112.0±12.0	51.8	2.16
		V	19	M	122.0±11.0	49.3	2.47
		V	19	F	97.5± 9.2	55.4	1.75
		V	21	M	130.0± 9.7	46.0	2.82
	S.C.	V	21	M	104.0±15.0	57.6	1.80
		V	21	M	98.6± 8.3	49.0	2.01
	Md	V	22	M	163.0±11.0	46.1	3.53
	S.C.	V	22	M	71.9± 7.3	50.3	1.42
	Md	V	23	M	73.9± 9.7	53.9	1.37
		V	23	M	120.0±10.0	62.0	1.93
		V	24	M	59.3± 6.9	39.4	1.50
		V	24	M	108.0±12.0	61.6	1.75
Central:	Wisc	V	0	F	180.0±22.0	55.0	3.27
		V	0	M	125.0±16.0	55.0	2.27
	Mich	V	3	F	91.6± 8.8	31.9	2.87
	Minn	V	4	F	82.2± 7.4	22.8	3.60
		V	4	F	111.0± 9.2	30.5	3.63
	Wisc	V	5	M	185.0±14.0	44.6	4.14
	Ohio	V	7	M	234.0±16.0	70.0	3.34
		V	9	F	186.0±18.0	93.3	1.99
	Wisc	V	9	M	37.4± 6.3	26.9	1.39
	Ohio	V	9	M	138.0±12.0	55.7	2.47
		V	12	F	124.0±34.0	65.3	1.89
	Mich	V	14	F	89.5± 8.8	37.4	2.39
	Ohio	V	14	M	119.0±11.0	50.5	2.35
		V	14	M	122.0±13.0	56.2	2.17
	Minn	V	16	F	52.6± 6.4	28.2	1.86
	Mich	V	17	M	80.0±12.0	56.8	1.40
	Ohio	V	18	M	164.0±12.0	57.6	2.84
		V	19	F	102.0±12.0	75.6	1.34
	Minn	V	19	M	86.8± 7.5	43.9	1.97
	Ohio	V	20	M	93.8±12.0	61.3	1.53
		V	20	M	210.0±22.0	82.0	2.56
		V	21	M	107.0±13.0	56.9	1.88
		V	24	M	90.0±12.0	75.3	1.19
		V	24	M	117.0±13.0	67.2	1.74
	Miss	V	25	F	125.0±14.0	51.1	2.44

See footnotes at end of table.

Table 1. Strontium-90 in human bone, July–September 1968—Continued

Bone region and State		Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northwest:	Ore	V	0	M	155.0±14.0	50.8	3.05
		V	1	M	90.7± 9.3	47.3	1.91
		V	4	F	33.2± 5.1	27.5	1.20
		V	6	F	50.1± 6.5	32.8	1.52
		V	8	M	65.7± 8.5	34.3	1.91
		V	8	F	43.3± 6.8	29.3	1.48
		V	9	M	89.0± 8.4	33.0	2.69
		V	12	M	56.9± 6.3	33.8	1.64
		V	12	M	58.9± 6.3	35.8	1.64
		V	13	M	286.0±19.0	104.0	2.75
		V	16	M	124.0±10.0	47.0	2.64
	Wash	V	17	M	146.0±11.0	58.2	2.50
	Ore	V	18	M	122.0±12.0	49.7	2.45
		V	18	F	88.9± 8.2	51.6	1.72
		V	18	F	99.1±12.0	52.6	1.88
		V	21	M	99.9±12.0	59.6	1.67
		V	22	M	78.1± 7.4	48.3	1.61
		V	22	M	110.0±12.0	50.5	2.17
Southwest:	Tex	V	0	M	201.0±19.0	33.1	6.06
	Colo	V	7	M	110.0±16.0	56.7	1.94
	Tex	V	11	F	97.4± 9.7	33.7	2.91
	Colo	V	13	F	77.0±13.0	40.7	1.89
		V	15	M	96.1± 9.7	42.5	2.26
		V	16	M	155.0±13.0	54.9	2.82
		V	17	F	129.0±12.0	61.1	2.11
		V	18	F	96.5±12.0	52.9	1.82
		V	18	M	92.9± 8.2	45.7	2.03
		V	19	M	56.0±11.0	38.3	1.46
		V	20	M	99.1± 8.9	51.9	1.90
	Calif	V	21	M	64.2±10.0	51.8	1.23
	Colo	V	22	F	60.8± 8.8	50.7	1.19
		V	22	M	64.3± 7.9	48.4	1.32
		V	23	F	82.5± 9.4	52.3	1.57
		V	24	F	110.0±13.0	57.0	1.92
		V	24	M	72.8±10.0	50.7	1.43
North:	Alaska	R	20	M	305.0±34.0	132.0	2.31

[a] Type of bone: vertebrae, V; rib, R; sternum, S; tibia, T.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

where (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is than calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium-90) are analyzed periodically.

The analytical results for strontium-90 in individual bones from persons dying during the third quarter (July–September) of 1968 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	October 1968
October–December 1967	February 1969
January–March 1968	April 1969
April–June 1968	July 1969

REFERENCE

(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1 Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964)

(*5*) HALLISEY. R. M. and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–9 (August 1967).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Hanford Atomic Products Operation and the Los Alamos Scientific Laboratory.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Hanford Atomic Products Operation[2] Calendar Year 1967

Battelle Memorial Institute
Richland, Washington

A variety of radioactive wastes are generated by the Hanford production reactors, chemical separations plants, and laboratories. High level wastes are concentrated and retained in storage within the project boundaries. Controlled releases of low-level wastes, for which concentration and storage are not feasible, are made to the ground, to the atmosphere, and to the Columbia River. The Atomic Energy Commission (AEC) regulations governing radioactive waste disposal at Hanford are described in the AEC Manual Chapter RL 0510 (*1*). During 1967, the plant facilities were operated for the AEC by: Atlantic Richfield Hanford Company; Pacific Northwest Laboratory of Battelle Memorial Institute: Douglas United Nuclear, Incorporated; Isochem, Incorporated; and ITT Federal Support Services, Incorporated.

The Hanford plant is located in a semiarid region of southeastern Washington State, where the average annual rainfall is about 16 cm (6 in.). This section of the State has a sparse covering of natural vegetation primarily suited for grazing, although large areas near the project have gradually been put under irrigation during the past few years. The plant site (figure 1) covers an area of about 1,300 km^2 (500 square miles). The Columbia River flows through the northern edge of the project and forms part of the eastern boundary. Near the plant production sites, the prevailing winds are from the northwest with strong drainage and crosswinds causing distorted flow patterns. The meteorology of the region is typical of desert areas with frequent strong inversions occurring at night and breaking during the day to provide unstable and turbulent conditions.

The populated area of primary interest is the tri-cities area (Richland, Pasco, and Kennewick) situated on the Columbia River directly downstream from the plant (figure 1). Smaller communities in the vicinity are Benton City, West Richland, Mesa, and Othello. The population of the communities near the plant, together with the surrounding agricultural area, is about 90,000.

Sources and levels of environmental radioactivity

Low-level wastes from plant operations, fallout from nuclear weapons testing, naturally-occurring radionuclides, and cosmic rays contribute to radiation levels in the Hanford environs. Hanford operations that could contribute to radioactivity outside the plant boundary are, the disposal of reactor cooling water to the Columbia River, stack releases at the chemical separations areas and laboratory areas, and disposal of radioactive wastes to ground.

The most significant Hanford contribution to off-plant radioactivity and population doses usually originates with reactor cooling water releases to the Columbia River. Although airborne re-

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[2] Summarized from Pacific Northwest Laboratory, Evaluation of Radiological Conditions in the Vicinity of Hanford for 1967, BNWL-983 (March 1969).

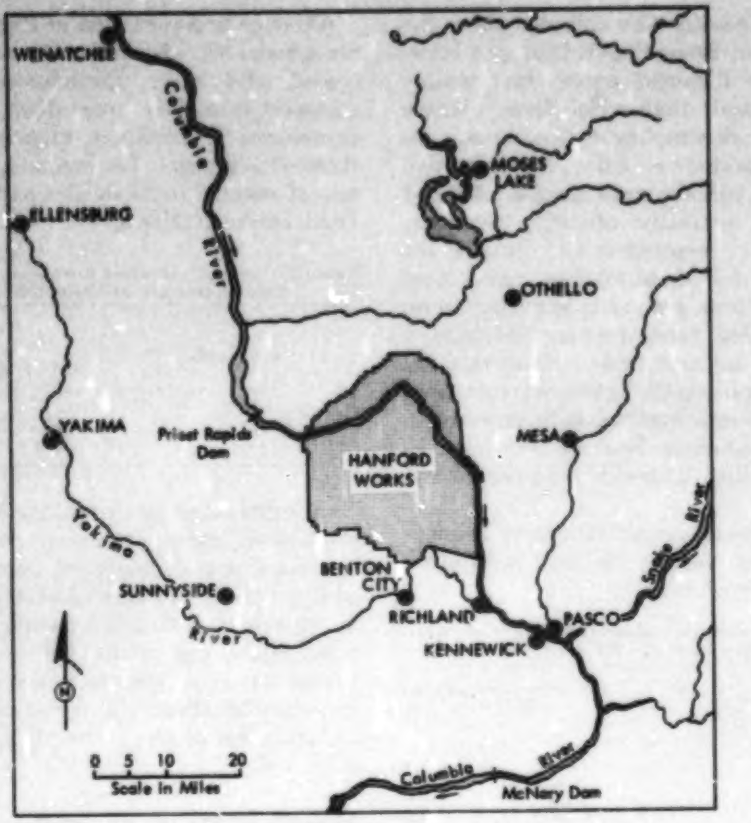
WENATCHEE
Columbia River
MOSES LAKE
ELLENSBURG
OTHELLO
YAKIMA
Priest Rapids Dam
HANFORD WORKS
MESA
Snake River
Yakima River
SUNNYSIDE
BENTON CITY
RICHLAND
PASCO
KENNEWICK
N
0 5 10 20
Scale in Miles
Columbia River
McNary Dam

Figure 1. Hanford project environs

leases of iodine-131 contributed to the thyroid doses of the local population, the major portion of the thyroid dose in 1967 resulted from radioiodines in drinking water.

Noteworthy events during 1967 included the June shutdown of D reactor, the fourth Hanford production reactor to be retired since 1964. The Redox separations plant was also retired from routine operation. Abrupt but temporary increases in iodine-131 concentrations in environmental media in January 1967 were attributed to an announced foreign weapons test.

Radioactivity in the Columbia River

All of Hanford's production reactors use Columbia River water for cooling. The N-reactor uses recirculating demineralized water as a primary coolant. All wastewater containing significant amounts of radioactive materials is filtered through the ground before it reaches the river. The amount of radioactive material reaching the river from N-reactor is a negligibly small fraction of that released from the older reactors.

At the older reactors, some elements present in the cooling water are transformed into radionuclides during the single pass through the reactors. In addition, radioactive materials formed on the surfaces of fuel elements and process tubes are eventually carried away by the cooling water to the river.

Many of the radionuclides formed in reactor cooling water are short-lived and decay rapidly after formation. In addition to radioactive decay, some fraction of most radionuclides is removed from the river water by sedimentation and uptake by aquatic organisms. Relatively small amounts of fission products are present in the river because of occasional ruptures of the fuel element jackets and fallout from nuclear weapons testing.

Samples of river water were collected above the production areas at Priest Rapids Dam and below the areas at the Richland water plant intake, McNary Dam and Bonneville Dam. Where possible, cumulative sampling equipment was installed and provided a more representative sample than the periodic grap samples obtained in the past. This cumulative sampling technique, however, makes it impractical to calculate the amounts of very short-lived nuclides; these must still be measured from grab samples. Comparison of 1967 with 1965 concentrations indicates a general reduction for most radionuclides with the exception of phosphorus-32. Lower concentrations of the short-lived radionuclides were expected in 1967 because production reactors remaining in operation are further upstream than the retired reactors.

The annual average concentrations of radionuclides measured routinely at Richland and Bonneville Dam are shown in table 1.

Table 1. Annual average radioactivity in Columbia River water, 1967

Radioactivity	Radioactivity concentration (pCi/liter)	
	Richland	Bonneville Dam
Rare earths + yttrium	390	(a)
Sodium-24	2,600	(a)
Phosphorus-32	190	25
Chromium-51	3,200	1,400
Copper-64	2,000	(a)
Zinc-65	220	62
Arsenic-76	400	(a)
Strontium-90	1	(a)
Antimony-122	150	(a)
Iodine-131	8	3
Neptunium-239	1,100	(a)

[a] Insufficient sampling data to provide a meaningful annual average.

Measurements on traverses across the river at Richland indicate a slightly nonuniform distribution of the longer-lived radioisotopes at this cross-section. Entries of the Yakima River some 16 km (10 miles) above Pasco and of the Snake River some 48 km (30 miles) above McNary Dam slightly influence the distribution of radionuclides below these two points. The magnitude of the influence varies with seasonal changes in the flow rate of the tributaries. Bonneville Dam is approximately 490 km (305 miles) below the Hanford reactors and represents the furthest downstream location where river water is routinely sampled for Hanford's environmental surveillance program.

Although transport rates at Richland in 1967 for phosphorus-32, chromium-51, and zinc-65 exceeded 1966 values, chromium-51, and zinc-65, transport rates were lower than in 1965 or 1964; phosphorus-32 transport rates were similar to those of past years. The annual average transport rate of selected radionuclides past the Bonneville Dam is given in table 2.

Table 2. Annual average transport rate past Bonneville Dam of selected radionuclides, 1964–1967

Radionuclide	Transport rate (Ci/day)			
	1964	1965	1966	1967
Phosphorus-32	12	11	9	12
Chromium-51	860	900	420	610
Zinc-65	44	49	21	40

An estimate of the inventory of those radionuclides which exist in the ocean may be calculated by assuming an equilibrium between the rate of addition from the river and the rate of decay in the ocean. A constant rate of entry into the ocean equivalent to that indicated by the 1967 Bonneville Dam measurements would imply an inventory of about 250 curies of phosphorus-32, 24,000 curies of chromium-51, and 14,000 curies of zinc-65.

Radionuclides in drinking water

The city of Richland is the first community downstream from the Hanford reactors that uses the Columbia River as a source of drinking water. Pasco and Kennewick, a few miles farther downstream, also use the Columbia River as a source of drinking water. Continuous potable water samples were collected at the Richland and Pasco water plants, and periodic samples were collected at Kennewick. All of these samples were analyzed for the important individual radionuclides. The results of analyses of drinking water from these three cities are summarized in table 3.

The concentations of short-lived radionuclides in the water at the time it is consumed are less than shown in table 3 because there is a significant transport time between the water plant and most consumers. The transport time may vary from hours to days depending upon the location of customers on the distribution system and the water demand.

Table 3. Annual average concentration of radioactivity measured in drinking water, 1967

Radionuclides	Radioactivity concentration (pCi/liter)		
	Richland	Pasco	Kennewick
Rare earths + yttrium	87	46	(a)
Sodium-24	1,700	790	94
Phosphorus-32	58	52	15
Chromium-51	3,100	2,700	1,200
Copper-64	570	160	44
Zinc-65	86	65	<20
Arsenic-76	160	56	16
Strontium-90	1	1	(a)
Iodine-131	8	6	<2
Antimony-122	140	120	18
Neptunium-239	600	420	55

[a] Insufficient data to provide a meaningf ul annual average.

The calculated annual average dose to whole body, the GI tract, and thyroid, and the percent maximum permissible rate of intake (MPRI) for bone from sustained consumption of drinking water throughout the year are presented in table 4 for the three cities.

Table 4. Calculated annual dose for selected organs from routine ingestion of drinking water, 1967[a]

Location	Whole body (mrem)	GI tract (mrem)	Bone (percent of MPRI)	Thyroid small child (0.4 liter/day) (mrem)
Richland	1.7	28	0.5	41
Pasco	1.1	15	.1	35
Kennewick	<1	2.8	<.1	13

[a] Here and elsewhere in this report where a dose (mrem) from an ingested nuclide is expressed, the determination is made from parameters used by the ICRP to translate dose rates into maximum permissible concentrations for drinking water. In most cases, the estimated annual intakes of individual radionuclides were multiplied by conversion factors derived from the ICRP parameters and published by Vennart and Minski (*8*).

Note: The "standard man" average intake rate of 1.2 liter/day was used in this calculation (*5*).

The estimated GI tract dose to Pasco residents from the measured radionuclides in drinking water was somewhat higher in 1967 (15 mrem) than in 1966 (11 mrem) because of the extended shutdown of all reactors during the summer of 1966 (*4,5*). However, the calculated GI tract dose for Richland residents was lower in 1967 (28 mrem) than was reported for 1966 (34 mrem). The major reason for the apparently reduced dose at Richland was a change in the basis for the calculation. Measurements from a continuous monitor of gross radioactivity in the Richland drinking water were substituted during part of the year for complete reliance on periodic "grab" sampling. The infant thyroid dose appears somewhat higher during 1967 than during 1966 (*6*) because a contribution from iodine-133 was included in the 1967 estimate. Without the increment from iodine-133, the estimated thyroid dose for 1967 would have been lower than for 1966.

Radionuclides in Columbia River fish

The quantities and kinds of fish caught by local fishermen have been previously estimated from surveys carried out from 1963 to 1965 in cooperation with the Washington State Game Department. The maximum estimate of consumption by the fishermen interviewed was 200 meals/yr of panfish species (crappie, perch, and bass) taken from the Columbia River.

From this species distribution and radiochemical analyses of the specimens collected (*7*) the maximum fish consumer would have received intakes during 1967 of 1.6 μCi phosphorus-32 and 0.4 μCi zinc-65. Such an intake would have amounted to 10 percent of the maximum permissible intake with bone as the critical organ. Comparable values for 1966 were 1.0 μCi phosphorus-32 and 0.5 μCi zinc-65.

The average consumption of Columbia River fish by Richland residents was estimated from plant employee diet questionnaires. With the use of the same mixture of species as for the maximum fish consumer, the average intake during 1967 was 0.019 μCi phosphorus-32 and 0.004 μCi zinc-65, or about 0.1 percent of the MPRI with bone as the critical organ.

Radionuclides in shellfish

Zinc-65 and phosphorus-32 are the only radionuclides in the reactor effluent that are found in sufficient abundance beyond the mouth of the Columbia River to be of radiological interest. Oysters have been found to contain higher concentratons of zinc-65 than other common seafoods. In the case of phosphorus-32, a normal seasonal minimum occurs in the late summer. In August 1967, phosphorus-32 concentrations were below 1 pCi/g and remained at this low level through December. The annual average concentrations of 30 pCi/g of zinc-65 and 3.3 pCi/g phosphorus-32 for 1967 were similar to those of 1966.

Consumption of oysters containing these concentrations at the rate of 50 g/day (*8*) would result in an annual dose of about 6 mrem to the GI

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tract and 4 mrem to the whole body. These intakes represent 0.4 percent of the MPRI for bone as the critical organ.

Radionuclides in the atmosphere

At Hanford, gaseous waste from the chemical separation facilities is released to the atmosphere through 70 m high (230 feet) stacks after most of the radioactive materials have been removed by filtration and scrubbing. These radioactive materials are primarily associated with process vessel off-gases. Ventilation air from laboratory and reactor building contains comparatively minor amounts of radioactive materials under normal operating conditions.

Measurements of airborne iodine-131 were made routinely at numerous locations within the Hanford reservation and around the plant perimeter. The results of iodine-131 measurements for the past few years are summarized in table 5.

The four locations listed in table 5 lie within a 45° sector southeast to south of these separations center. Such concentrations sustained in inspired air imply an annual dose to the thyroid of the "standard man" of less than 1 mrem.

Table 5. Annual average iodine-131 concentrations in the atmosphere 1964–1967

Location	Distance from separation stacks (miles)	Iodine-131 (pCi/m)			
		1964	1965	1966	1967
Prosser barricade[a]	14	0.02	0.03	0.02	0.02
Benton City	20	.06	.03	.01	.02
Richland	23	.02	.02	.01	.02
Pasco	32	.01	.03	.01	.02

[a] Installed during October 1963.

Air filter sampling is maintained at several locations within the Hanford reservation and around the plant perimeter. Air filter results are not used in estimating exposure but serve to illustrate the trends in atmospheric contamination. Sudden changes in concentration are used to signal the need for shifted emphasis in other portions of the environmental monitoring program related to atmospheric contamination.

Radionuclides in milk and produce

The radioactivity found in locally grown agricultural produce can be influenced by deposition of airborne radionuclides or by irrigation with river water containing reactor effluent radionuclides. The chemical separations facilities are generally the principal local source of airborne radionuclides. The closest farming area to the separations facilities is about 21 km (13 miles) away.

Most irrigated farms near the Hanford plant use water drawn from the Yakima River, or from the Columbia River above the project. There are, however, two small areas which regularly take water from the Columbia River downstream from the reactors for irrigation. They are the Ringold farms and the Riverview district west of Pasco, located respectively 25 and 40 miles downstream from the reactors.

The principal products from the larger farm plots are hay, fruit, beef, and dairy products. This area is centered 48 km (30 miles) southeast of the chemical separations plants. Another agricultural area near the project is Benton City, located on the Yakima River about 20 miles (32 km) directly south of the separations facilities.

The milk surveillance program maintained during 1967 included samples from local farms and dairies and from commercial supplies available to people in the tri-cities. The concentrations of radionuclides found in milk sold by commercial outlets were similar to that reported by the U.S. Public Health Service and the Washington State Department of Health. Milk from local farms irrigated with water drawn from the river downstream from the reactors contained phosphorus-32, zinc-65, and iodine-131, as well as fission products of fallout origin.

Generally, the average concentration of iodine-131 in both local and commercial milk was near or below the analytical limit of 3 pCi/liter, except for a sharp increase during an influx of fresh fallout in January. Brief increases were noted in May following small transient increases in the release rates of iodine-131 from a chemical separations facility. The average concentration of iodine-131 in milk observed for the year was 4 pCi/liter.

Dairy farms in the Ringold and Riverview area that utilize the Columbia River for irrigation of pasture land and hay fields produce milk containing both phosphorus-32 and zinc-65. During 1967, the average concentration of phosphorus-32 in milk from Ringold and Riverview farms was 320 pCi/liter and the average concentration of zinc-65 was 200 pCi/liter. Commercial milk distributed in the Tri-Cities usually does not contain detectable phosphorus-32 and zinc-65 because it is obtained principally from farms not irrigated with Columbia River water.

Adult residents consuming milk (1 liter/day) obtained from the Ringold-Riverview area would receive an annual dose from phosphorus-32 and zinc-65 amounting to about 3 mrem to the GI tract and 1.3 mrem to the whole body. The intake of phosphorus-32 and zinc-65 would be equal to about 0.7 percent of the MPRI for bone. The intake of iodine-131 would have resulted in a dose of about 25 mrem to the 2 g thyroid of an infant.

Miscellaneous fresh farm produce was sampled periodically for radioanalysis during the 1967 growing season from local farms and commercial outlets. Results of these measurements were similar to those of previous years (4-5) and indicated that only small quantities of radionuclides are present in locally-grown produce.

The concentrations of iodine-131 found in samples of fresh vegetables collected from local farms and markets during the period of May through September 1967 were less than or approximately equal to the analytical limit of 0.05 pCi/g. If these fresh vegetables had been consumed at the rate of 100 g/day throughout the 5-month period the average intake from this source would have been about 380 pCi for iodine-131, based on an assumed average concentration of 0.025 pCi/g. Such an intake would imply an annual dose of about 0.6 mrem to the thyroid of an adult. An intake of 50 grams per day of the same vegetable by a small child would imply an annual dose of about 4 mrem to a 2 g thyroid.

Concentrations of iodine-131 in cattle thyroids

Thyroids of cattle are collected periodically from slaughter houses in Moses Lake, Yakima, Walla Walla, Wenatchee, and Pasco, and are sent to Hanford for radioanalysis. The maximum concentration of 160 pCi iodine-131/g of thyroid was a single sample collected in January 1967 at Walla Walla following an announced foreign nuclear weapons test.

External radiation

Ionization chambers are stationed on the Hanford reservation and in Richland to estimate the gamma radiation exposure from external sources. Measurements in air 1 meter above ground during 1967 averaged about 0.35 mR/day or 130 mR/yr at Hanford and about 0.26 mR/day or 100 mR/yr at Richland. Essentially all of the exposure is from natural background and worldwide fallout from nuclear weapons testing.

Direct radiation measurements are also made in the Columbia River at several locations with pocket-type ionization chambers submerged 0.6 to 1.5 meters (2 to 5 feet) below the surface of the water. Exposure rates are higher in the river than over ground because of the presence of gamma-ray emitters (especially sodium-24) in reactor effluent. In the vicinity of Richland, the average exposure rate in the water during the months of April through October was about 2.5 mR/day. A person swimming or boating in the river for a total of 240 hours during the year could have received a whole-body exposure of 25 mR.

An estimate of the external radiation exposure received by people that fish from the shore in the vicinity of the Hanford project is made from routine measurements at the river shoreline. Recent measurements of the gamma-ray spectrum indicate that zinc-65 and scandium-46 accumulated by algal growth on the substrate at the river's edge is responsible for a major portion of a fisherman's radiation exposure. Assuming that an avid fisherman spent as many as 500 hours on the river bank in the vicinity of Richland during 1967, his external exposure could have been about 11 mR.

Radioactivity in ground water

Depending upon their burden of radionuclides, liquid wastes from the chemical separations areas are routed to various facilities. High-level wastes are stored in underground concrete tanks lined with steel. Intermediate-level wastes are sent to underground "cribs" from which they percolate into the soil. The areas selected for intermediate waste disposal and high-level waste storage have soil with good ion exchange capacity and ground water depths of 50 to 100 m (165 to 330 feet). Low-level wastes (usually containing <50 pCi/ml) are sent to depressions in the ground where surface ponds or "swamps" have been formed as a result of the continuous addition of the relatively large volumes of water. Wells have been drilled in and around crib and tank storage areas to detect any leaks in the tanks and to measure radionuclides that have reached the ground water.

The bulk of this radioactive material is hydrogen-3 and ruthenium-rhodium-106.

In all probability, some radionuclides from the chemical processing areas are now entering the Columbia River. However, the contribution of these nuclides is too small to be detectable in the river water and any exposure from them is therefore negligible.

Fallout from nuclear weapons testing

In addition to the radiation dose received by residents of the Hanford environs from Hanford-originated radionuclides and from natural background radiation, a dose increment due to fallout nuclides is also received. Locally this increment is below the national average because of the low rainfall in this region (6.3 inches/year). Measurements of fallout, like measurements of natural background radiation, are necessary to place the radiation dose resulting from Hanford operations into proper perspective. Table 6 shows a summary of the estimated annual doses from fallout nuclides present in the Hanford environs. The MPRI's for strontium-90 are derived from Federal Radiation Council Guides (*9*).

Table 6. Annual radiation dose from fallout radionuclides, 1967

Radionuclide	Organ	Radiation dose (mrem)		
		Maximum individual	Typical Richland resident	Average Richland resident
Tritium	Whole body	<1	<1	<1
Strontium-90	GI tract	<1	<1	<1
	Whole body	3	3	<2
	Bone	(1 percent MPRI)	(4 percent MPRI)	(3 percent MPRI)
Cesium-137	GI tract	<1	<1	<1
	Whole body	2	<1	<1
	Bone	(0.2 percent MPRI)	(0.1 percent MPRI)	(0.1 percent MPRI)

The maximum individual

Experience accumulated from the environmental surveillance program and associated research studies indicates that those individuals receiving the greatest percentage of permissible radiation dose from Hanford sources, the "maximum" individual, consume some combination of the following: fish caught locally in the Columbia River; game birds shot near the river; foodstuffs produced on local farms irrigated with Columbia River water drawn from below the reactors; and municipal water with the Columbia River as the source.

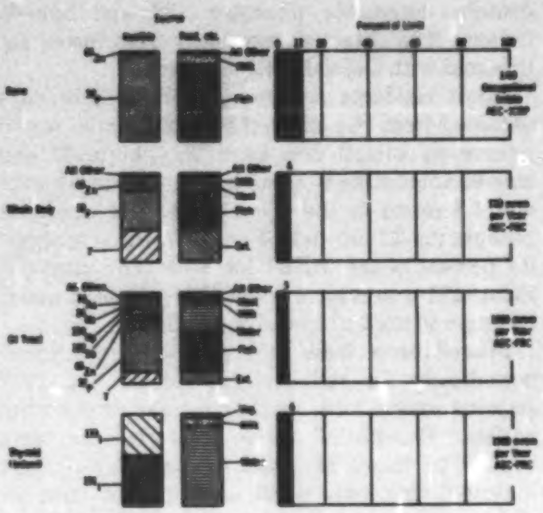

Figure 2. Estimated dose to "maximum" individual

The composite dose for this "maximum" individual is summarized in table 7 (figure 2). Estimated doses to the GI tract for the "maximum" individual during 1967 and 1966 were both about 5 percent of the appropriate limit, with phosphorus-32 contributing about 50 percent of the total dose in each case. The 1967 GI tract dose was 82 mrem. For the whole body dose, 32 mrem or about 6 percent of the appropriate limit, the 1967 estimate was not significantly different from the 1966 estimate of 31 mrem. The estimated percent of the maximum permissible rate of intake for bone as the critical organ was 12 percent during 1967, compared to 10 percent for 1966.

In the case of the thyroid gland, the highest radiation doses are those received by infants because of the relatively small thyroid mass (assumed to be 2 g). This value is similar to the maximum infant thyroid dose estimated for 1966. However. the estimates are not directly comparable, because estimates of thyroid dose for 1967, unlike that for 1966, included contributions from both iodine-131 and iodine-133 in the drinking water. The estimate of iodine-133 intake by the maximum Richland infant gave a contribution to the thyroid dose of 47 mrem for 1967 or about one-half of the total.

Table 8 shows the trend of "maximum" individual dose estimates for the period 1964-1967.

Table 7. Summary of radiation doses in uncontrolled areas of Hanford environs 1967[a]

Organ	Maximum individual			Typical Richland resident		
	Annual dose (mrem)	Limit (mrem)	Percent of limit	Annual dose (mrem)	Limit (mrem)	Percent of limit
GI tract	82	1,500	5	24	500	5
Thyroid (infant)	97	1,500	6	50	500	10
Whole body	32	500	6	4	170	3
Bone	([b])	([c])	12	([b])	([d])	.6

[a] Represents individuals or population groups residing in uncontrolled areas near the Hanford plant.
[b] Bone dose not calculated. Exposure relative to permissible exposure determined on the basis of MPRI.
[c] ICRP MPRI for "maximum individual"—16 μCi ^{32}P/yr and 800 μCi ^{65}Zn/yr.
[d] ICRP MPRI for "typical Richland resident"—5.3 μCi ^{32}P/yr and 270 μCi ^{65}Zn/yr.

Table 8. Dose estimates for maximum individual,[a] **1964 to 1967**

Organ	Percent of limit				Limit (mrem)
	1964	1965	1966	1967	
GI tract	9	6	5	5	1.500
Whole body	18	8	7	6	500
Bone	23	12	10	12	
Thyroid (infant)	5	4	6	[b] 3	1.500

[a] Does not include fallout and natural background.
[b] For comparison, includes dose from iodine-131 only.

The 1967 thyroid dose has been adjusted to a comparable basis (from iodine-131 only). The increase observed in the thyroid dose during 1966 reflects an unusual release of radioiodine to the Columbia River from a production reactor (*9*). The long trend for whole body and GI tract doses is obviously downward. Bone doses for the "maximum" individual, which appear to have leveled off at about 10 to 12 percent of the MPRI for the past 3 years, are heavily dependent upon phosphorus-32 concentrations in Columbia River fish. The latter concentrations are, in turn, dependent on river conditions as well as radionuclide release rates. The 1966 estimate reflects, to some extent, the extended reactor outage of that year (*9*).

The typical Richland resident

The majority of people who live in Richland obtain their food from local commercial stores (rather than from farms) and consume little or no Columbia River fish or local game birds. The principal soure of radionuclides of Hanford origin ingested by such people is drinking water obtained from the Columbia River. For continuity with previous years, the doses for several organs of the body for the typical Richland resident have been calculated for 1967 (table 7 and figure 3).

For comparison, whole body doses from natural background and from fallout in this region are estimated at about 100 mrem/yr and 3 mrem/yr, respectively.

Conclusion

During 1967, the environmental surveillance program of the Hanford environs again showed that

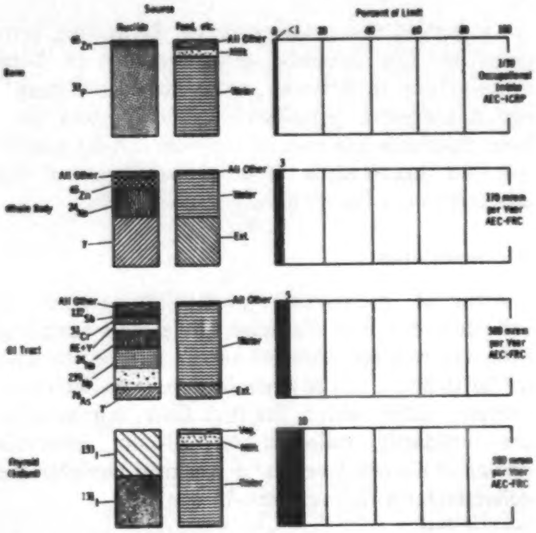

Figure 3. Estimated dose to "typical" Richland resident

the amounts of radioactive materials present were well within nationally accepted limits at all times. The only estimate exceeding one-tenth of the appropriate limit was 12 percent MPRI for the bone of the hypothetical "maximum" individual. Because of the 1966 reactor outage, some 1967 dose estimates for the environmental population exceeded 1966 levels, but not 1965 levels. The shutdown of plant facilities and process improvements have both contributed to a decrease in most dose estimates from 1965 to 1967.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Calendar year 1966	February 1968

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2. Los Alamos Scientific Laboratory[3]
Calender Year 1968

University of California
Los Alamos, New Mexico

As part of the environmental monitoring program at Los Alamos, measurements of beta radioactivity in airborne particulates and precipitation are made periodically. The samples have been taken on the roof of building TA-50 (about one and three-fourths of a mile southeast of the administrative building) since March 1963.

Air monitoring

Airborne radioactive particulate matter is collected on 4-inch-diameter filters. The sampling rate was reduced from 46 m^3/hr in 1962 to 25.5 m^3/hr in 1963, due to the addition of an activated charcoal filter behind the first filter. Air samples are ordinarily collected for 24-hour intervals during the work week, and weekend samples are collected for a 72-hour period.

The filters are counted for beta radioactivity 7 days after collection in a thin-window gas (methane) flow proportional counter with an overall efficiency of 50 percent for strontium-yttruim-90.

Precipitation monitoring

Collection is made in a 0.4 square meter rain collector which delivers 1 liter of water for each 0.1 inch of precipitation. It has been found that this arrangement collected radioactivity even during relatively dry periods. By washing down the sides of the collector with 1 liter of distilled water, a suitable sample is obtained. These "wash" samples, as well as any precipitation, are reduced in volume, dry-plated on 1-inch stainless-steel planchets, and counted in an automatic beta-particle system, employing a gas-flow proportional, alpha and beta chamber. A cosmic-ray umbrella with coincidence counter cancel provides a low background for the system.

Results

Average daily radioactivity concentrations for air collected are weighted for sample periods of more than 1 day. Average radioactivity concentrations for the precipitation collection are calculated from the total radioactivity collected during the month divided by the number of days in the month. Summary of air data (pCi/m^3) shows the maximum, 1.45; minimum, 0.01; and average 0.17. Precipitation data (nCi/m^2) shows the maximum, 9.2; minimum, 0.001; and average, 3.2.

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[3] Summarized from "Beta Radioactivity in Environmental Air and Precipitation at Los Alamos, New Mexico, for 1968" (LA-4133).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
1967	November 1968

Reported Nuclear Detonations, August 1969

The U.S. Atomic Energy Commission announced that a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground at its Nevada Test Site on August 14, 1969.

On August 27, 1969, a nuclear test of low yield was conducted underground by the Atomic Energy Commission at its Nevada Test Site. The test had associated with it a pipe leading from the region of detonation to the surface. There was a minor release of radioactivity through the pipe to the surface which was confined to the immediate area of the detonation. Closure systems in the pipe prevented escape of any significant amount of radioactivity. The radioactivity was not detectable with sensitive instruments more than 2 miles from the detonation point.